

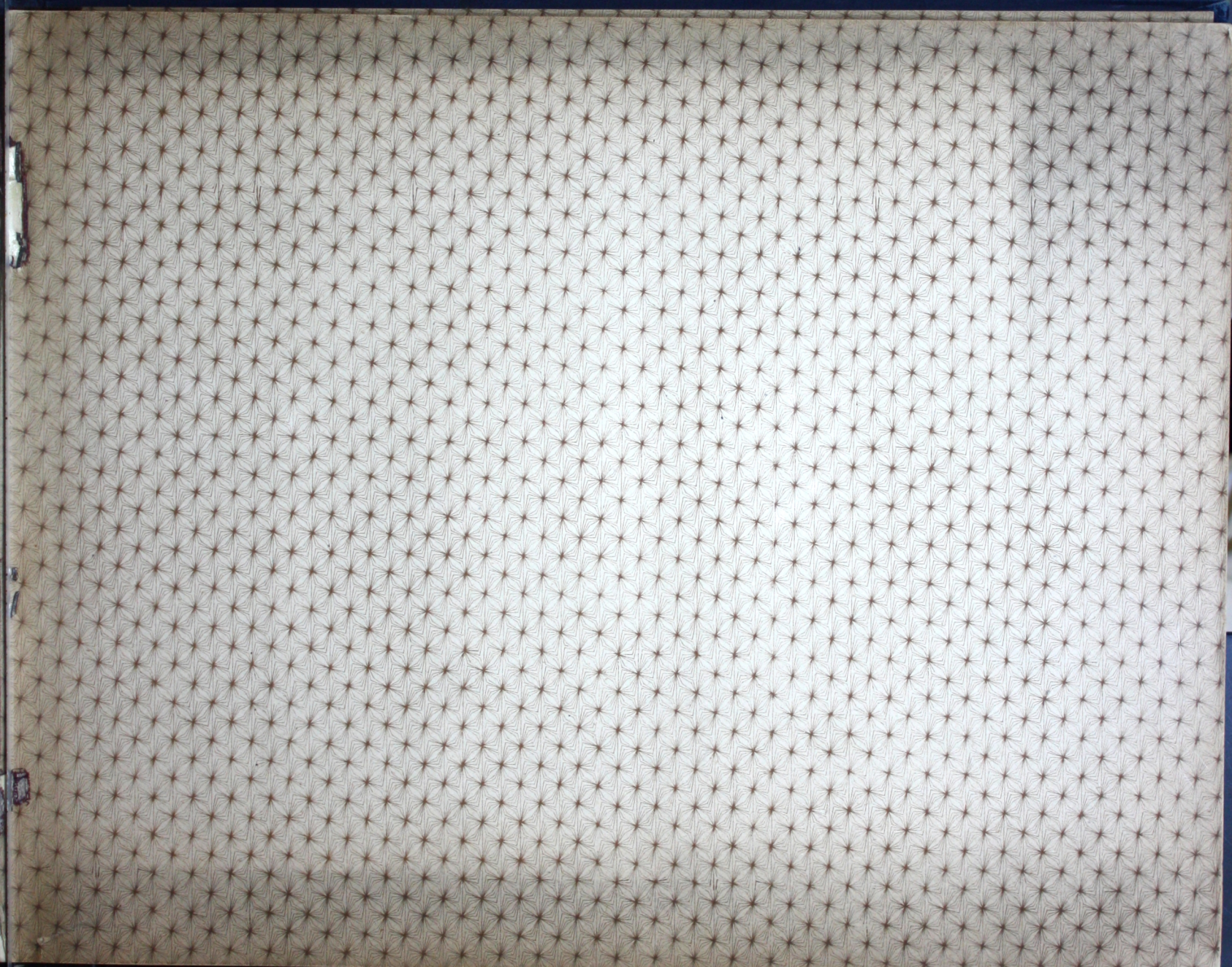
ALBUM OF DESIGNS
THE PHŒNIX BRIDGE COMPANY



PHŒNIXVILLE BRIDGE WORKS

A. S. Norton

No *E35* Whole No *90*





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THE PHŒNIX BRIDGE COMPANY.



[FRONTISPIECE.]

SCHUYLKILL RIVER BRIDGE,
ON THE LINE OF THE PHILADELPHIA AND READING RAILROAD, AT PHILADELPHIA, PA.

ALBUM OF DESIGNS
OF
THE PHOENIX BRIDGE COMPANY

SUCCESSORS TO CLARKE, REEVES & CO.

Phoenixville Bridge Works.

—*EDITION OF 1888.*—

OFFICES:

No. 410 Walnut Street, Philadelphia.

No. 49 William Street, New York.

At Works, Phoenixville, Pa.

Western Office: 118 West Sixth Street, Kansas City, Mo.

PRESS OF
J. B. LIPPINCOTT COMPANY.
PHILADELPHIA.
1888.

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THE WELLS & HOPE COMPANY.
PHILADELPHIA.

DAVID REEVES, President.
ADOLPHUS BONZANO, Vice-President and Chief Engineer.

WILLIAM H. REEVES, General Superintendent.
WILLIAM H. BURR, Assistant to Chief Engineer.

MORITZ G. LIPPERT, Chief of Drawing Room.
J. A. L. WADDELL, Engineer in Charge of Western Office.

GEORGE GERRY WHITE, Secretary.
FRANK T. DAVIS, Treasurer.

PHOENIXVILLE BRIDGE WORKS.

OFFICE OF

THE PHOENIX BRIDGE COMPANY.

Successors to CLARKE, REEVES & CO.,

Engineers, Contractors, and Builders of Bridges, Viaducts, Roofs, etc., of Iron and Steel,

No. 410 WALNUT STREET, PHILADELPHIA.

SINCE the presentation of our first album in 1870, the rapid increase in the variety and extent of our business, the design and manufacture of bridges and all kinds of structures of iron and steel, has rendered it necessary for us on frequently recurring occasions to exhibit to the public, and to our friends and customers particularly, the state of the various branches of constructive engineering as existing at the works of The Phoenix Bridge Company.

The present edition of the album represents the very latest features of bridge building, as well as the most recent constructions of viaducts, roofs, elevated railroads and other engineering structures as manufactured at these works at this date.

Since the reorganization of the Phoenixville Bridge Works, heretofore known under the firm-name of Clarke, Reeves & Co., the business has been conducted under the corporate title of The Phoenix Bridge Company. By this reorganization we have assumed the entire business of that firm, and have perfected arrangements with The Phoenix Iron Company, which give us additional facilities for concentrating the productive plant of that company upon the construction of our bridges, roofs, viaducts, piers, etc. Our present capacity thus reaches a yearly amount of 30,000 to 35,000 tons of finished material, with facilities which permit of further increase, if required by any unusual demand.

With machinery of the most improved character and an experience extending back almost to the very commencement of iron bridge-building in this country, it is believed that The Phoenix Bridge Company has unexcelled, if, indeed, equalled facilities for meeting the demands of the most advanced engineering practice.

It is our intention at the present, as it has been in the past, in the first place, to admit no material in our constructions except that of the very best quality, and which, by its nature, is best adapted to the resisting of the stresses acting upon it; and, in the second place, by a careful study of the circumstances of each case, to so design all parts, both main and detail, as to enable them to exert the resisting capacity of the metal in the simplest, most direct, and consequently most advantageous manner, thus attaining

that greatest desideratum in all correct constructive design, viz., combined economy of material and expense.

Our situation is such that the quality of the material entering into our constructions is completely under our control. Essentially, all of our material is produced by The Phoenix Iron Company, whose resources are so extensive and plant so complete that every stage of manufacture from the ore to the finished bar or shape is included within their works and performed on their premises. Thus every part of the process of production may be so adjusted and co-ordinated to the others, that any quality or grade of material best adapted to any particular construction may be secured with certainty. The high reputation of "Phoenix" iron for constructive purposes is undoubtedly due to this unity of design governing the effects of the different stages of production for the purpose of securing a definite end.

CHARACTER OF TRUSS.

Each individual type of truss possesses some particular merit of its own; but long experience in American bridge-practice has shown that the type originally developed by Pratt in wood and Whipple in iron, when designed in proper proportions, combines the greatest number of advantages for all usual circumstances. Our early selection and development of this truss for the great majority of ordinary cases, together with its later almost universal adoption in American practice, constitute gratifying evidences of the correctness of the general principles on which we have developed our designs.

Extraordinary circumstances, such as those of unusual length of span, difficulties of erection, etc., render advisable other types of truss, like the cantilever, or those with varying contours, or those having chords wholly or partially continuous.

Our varied facilities and extensive experience with such unusual structures, both in designing and erecting, enable us to meet the exigencies of those cases where they are

required, without loss of time and with the greatest economy, and by methods based upon the most advanced engineering practice.

DETAILS.

The design of details has received from us especial attention. We have regarded it as one of the most important departments of bridge-design, and have given it careful and continuous study in connection with the constantly varying and increasing demands of modern bridge-practice. It has been our endeavor to give the greatest possible simplicity to details, and so to dispose the material in them as to transfer stress in the most direct and simple manner, and by such a method to give to each main member precisely and only that kind of stress which it is intended to take.

All increments of chord-stress are brought to bear directly and symmetrically upon the full chord section, thus completely avoiding all bending and cumulative stresses. This result we deem of great importance in constructive design, though it frequently fails of that consideration which its importance demands.

By the attainment of these ends we are enabled in tension members to concentrate the metal truly along the centre lines of stress, and in compression-members to so dispose the sectional area as to enable it to act in the most advantageous manner possible, and thus to secure the most economical design.

Our forms of cross-section for compression-members, chief among which is the well-known "Phoenix" section, have been developed on the basis of the latest and most comprehensive column tests, in combination with the results of many years of experience in American practice with open and closed columns.

Whenever "Phoenix" columns are used, effective preservative processes are employed, before the column is closed, on all surfaces that are not afterwards open to inspection and painting, the columns are then closed absolutely tight. Such columns have been examined after fourteen to twenty years' use, and found to be not in the slightest degree affected by oxidation, though in some cases the columns had occupied most exposed positions in respect to extreme hygrometric changes in the atmosphere, and, in fact, had at times been under water for several days.

In open columns built of plates and angles, or of channels and plates, we dispose the metal in the most judicious manner, in view of the duties which it has to perform. By the use of well-designed latticing the requisite stiffness is secured, with ample facilities for constant inspection and painting at proper intervals.

In all cases, whether of closed or open columns, we aim to form a member in which the metal is placed far from the neutral axis, and whose parts shall be so self-supporting as to cause the column to fail as a whole, thus avoiding a weakness quite common to many latticed or other columns. The "Phoenix" column is, however, the only form which entirely fulfils this condition.

Although much yet remains to be done in the empirical determination of the resistance and proportions of long columns with various end conditions, yet sufficient tests have already been made upon full-size "Phoenix" and upon latticed and other forms of columns on the Government machine at Watertown, Mass., and at Phoenixville and elsewhere, to obtain correct ideas of the relative merits of some of the principal forms of section.

The following formulæ are expressive of those experimental results, which can be relied upon by engineers:

P = ultimate resistance in pounds per square inch of section.

l = length of column in inches.

r = radius of gyration in inches in direction of failure.

	Flat Ends.	Pin-Ends.
Phoenix Column.	$P = \frac{42,000}{1 + \frac{1}{50,000} \frac{l^2}{r^2}}$	$P = \frac{42,000}{1 + \frac{1}{30,000} \frac{l^2}{r^2}}$
Latticed, or Common Column.	$P = \frac{39,000}{1 + \frac{1}{40,000} \frac{l^2}{r^2}}$	$P = \frac{39,000}{1 + \frac{1}{30,000} \frac{l^2}{r^2}}$
Angle-Iron Struts.	$P = \frac{39,000}{1 + \frac{1}{30,000} \frac{l^2}{r^2}}$	$P = \frac{39,000}{1 + \frac{1}{16,000} \frac{l^2}{r^2}}$

The great superiority of the "Phoenix" column in resisting capacity is well shown by a comparison of these formulæ. They give results a little too low where the lengths become less than about 30 radii of gyration, with the exception of the last two, and a little too high when the lengths exceed 135 to 150 radii.

The formula for pin-end angle-struts is to be used only when the length exceeds 120 radii of gyration, as below that length the values of P for pin- and flat ends are shown by experiment to be the same,—i.e., for the pins used in the tests.

EYE-BARS.

In order to bring the design of eye-bar heads to a state of perfection, we have made many hundred tests on full-sized bars, and secured such a contour of head that the full resistance of the body of the bar will always be developed if it be tested to failure.

We are now prepared to die-forged the eye-bar head under the steam-hammer, or to form it by hydraulic pressure, as may be preferred.

RIVETED-WORK.

In the design of riveted-work we aim to produce results of the same general character as those obtained in the best pin-work. This is accomplished by placing the metal truly along the centre lines of stress, and causing the latter to intersect as nearly as possible at a single point at each joint.

The influence of the bearing pressure of the rivets against the intrados of the rivet-hole on the tensile resistance of the bars and plates, as well as the shearing of the rivets and other methods of rupture of the joints, are carefully considered in all designs. Bending- and other secondary stresses, so prevalent in nearly all riveted-work, and constituting, to some extent, at least, unavoidably inherent defects, are thus reduced to a minimum.

FLOOR SYSTEM.

There is probably no part of a railway bridge subjected to such destructive effects from the moving load as the floor system and its attachments to the truss proper at the chord-joints. The design of these parts has, therefore, received the care required by the difficult character of the duty which they have to perform. Our floor systems combine that degree of flexibility which enables them to sustain, with the least fatigue of the metal, the shock of a rapidly-passing train with such a judicious rigidity as to secure complete lateral stability and a perfect attachment to the truss proper. This attachment varies in character under different conditions. It consists of suspension loops, plate-hangers, or riveted or bolted connection directly to the vertical posts. In all cases the attachment is of such a character as to materially increase the lateral stability of the trusses, and effectually prevent any motion of the floor system as a whole or in any of its parts.

WIND-PRESSURE.

During the past few years American experience has shown that high-wind-pressures cannot be safely neglected in the design of any bridge structure. All our lateral and transverse systems of bracing are carefully designed both in reference to the highest recognized wind-pressure and the lateral vibration caused by rapidly-passing trains.

ROLLING LOADS.

The steady increase in railway rolling loads, which has taken place during the past ten years, has now caused it to reach a value of 148,000 pounds on a wheel-base of 13 feet 8 inches, or 164,000 pounds on a wheel-base of 21 feet 9 inches; or, again, 250,000 pounds on a base of 50 feet 3 inches. This corresponds to about the heaviest pattern of "consolidation" engine at present in use.

The moving or rolling load, however, should depend on the length of span, for the following simple reasons: If the span is very short, the four drivers (or a less number) of a consolidation engine may cover it, and thus subject it to an enormously heavy load, which will take a very high value per foot,—perhaps 8000 or 9000 pounds.

If, on the other hand, the span has a length of 100 feet and upwards, the general rolling load per foot will fall to an average of 4400 pounds, even if loaded with a train of consolidation locomotives. Hence it is that the rolling load varies from a very high value per foot for short spans to a comparatively low one for long spans.

But, again, a recognition of this difference is not sufficient. The stresses in many of the truss-members will be very much reduced below their proper value if the loads on the drivers and at other points be considered uniformly distributed. A correct system of computation, therefore, demands that the actual moving load, concentrated at drivers and other points, should be so placed as to give the greatest possible stress to the different truss-members. This is of special importance in connection with the floor system and its attachments to the chords. Our system of designing is based upon a correct recognition of these conditions.

GREATEST ALLOWABLE STRESS.

The greatest stress to which it is permissible to subject any portion of a bridge structure varies much both with its position in a given truss and the length of span.

The floor system and its attachments to chords are subjected to sudden loads and, comparatively speaking, violent shocks. The fatigue of the metal is correspondingly greater, and the greatest allowable stress should be correspondingly lower.

In the chords and main-web members the variations are much more gradual and less in relative amount; hence the working-stress may be larger. Again, the fixed load or weight of structure is much less in proportion to the moving load on short spans than for long ones. Hence the variation of stress, both relative and absolute, in passing from a loaded to an unloaded state, or *vice versa*, will be much greater in short spans than in long ones, thus necessitating the smaller working-stress for short spans.

The effects of these indirect influences, the importance of which has only been more fully developed by late investigations, have had almost their earliest application by this Company, which has, consequently, been among the first to be in position to utilize the advantage of investigations in the fatigue of metals.

UPSET SCREW-ENDS.

All of our upset screw-ends are from one-sixteenth of an inch to one-eighth of an inch larger at the bottom of screw-threads than the diameter of the rods, the ends of the rods being upset before the threads are cut. Many tests have shown the necessity of this arrangement, in order to develop the full strength of the body of the bar.

PLATE GIRDERS.

In the design of plate girders, it is to be borne in mind that the connection between the web and chords or flanges is not so intimate as in the case of rolled beams, and, further, that the stress in the cover-plates must be carried from the web to those plates first through the rivets between the web and chord-angles, then through the chord-angles to the rivets between the angles and cover-plates, and finally through the latter rivets to the cover-plates; hence, if there are a number of cover-plates, it will be essentially impossible to produce a satisfactory action in those farthest from the web, however accurately and solidly the riveting may be done. At the same time considerations of economy frequently forbid carrying the full centre section of the chord to the ends of the beam. The most judicious design is that one which avoids piling a number of thin plates at the centre of the span, but at the same time makes such a proper selection of angle-iron for chords that reduction to their section at and near the ends of the girders will produce the most economical construction.

Tests on full-sized girders have shown that, when the riveting is properly done, part of the web may be included with the chords in the resistance to bending. Parties, however, may specify whether they wish to have the web included or not.

Experiments on full-sized girders have also shown that a comparatively thin web will safely resist a much greater shear than is frequently allowed by many engineers. Indeed, it is a question whether there is not frequently a waste of material in the webs of large girders. Very thin webs are not permissible, on the ground that a very little deterioration, from corrosion or other cause, produces the destruction of a relatively large amount of metal; but web-plates of moderate thickness are not open to that objection, and if well stiffened at the ends, as well as at intervals of about one and a half times the depth, are sufficient for the heaviest girders.

The number and pitch of rivets should be determined by the amount of stress they have to carry from the web-plate to each part of the chord. This will usually necessitate a much smaller pitch near the ends than in the vicinity of the centre.

SPECIFICATIONS AND TESTS.

In cases where specifications are not furnished by the parties ordering of us, we use our Standard Specifications given elsewhere in this album. We may say here, however, briefly, that we design our structures for rapidly-passing loads, consisting of very heavy consolidation locomotives, with a weight of 96,000 pounds on a wheel-base of 14 feet 9 inches, or 171,000 pounds on a wheel-base of 45 feet 3 inches. This corresponds to nearly the heaviest locomotive now in use.

All machine and other work is of that high degree of excellence which has ever characterized the bridge-work of this Company.

We have three testing-machines of large capacity at the works of the Phoenix Iron Company, which are always in readiness for testing full-sized pieces or prepared specimens.

GENERAL DIRECTIONS.

Invitations for tenders and estimates should be accompanied by exact information on the following points:

Length of span in the clear, or from centre to centre of piers, or to back of abutments.

Angle between centre line of bridge and centre line of piers.

Whether on tangent or curve, and, if on the latter, the radius of the same.

Clear width between trusses.

Dimensions of tops of piers and abutments.

Height from base of rail to top of masonry.

Height from base of rail to extreme high water.

Whether floor system is on upper or lower chord.

Soundings along centre line of bridge, with the character of the bottom.

Specifications covering character and amount of moving load and limiting stresses.

A general statement of the character of the structure.

The nearest point of delivery to site of bridge by rail or water, and distance of haul, if any.

Whether railway company will furnish staging for erection or not.



LIST OF WROUGHT-IRON BRIDGES, VIADUCTS, AND PIERS,

BUILT AND NOW BUILDING BY

THE PHENIX BRIDGE COMPANY

Successors to CLARKE, REEVES & CO.,

FROM 1869 TO 1888.

FOR WHOM BUILT.	LOCATION.	Spans.		Total Length, Feet.	No. of Single Tracks.	FOR WHOM BUILT.	LOCATION.	Spans.		Total Length, Feet.	No. of Single Tracks.	FOR WHOM BUILT.	LOCATION.	Spans.		Total Length, Feet.	No. of Single Tracks.
		No.	Length, Feet.					No.	Length, Feet.					No.	Length, Feet.		
Chicago, Burlington & Quincy.	Burlington, Mo.	1	125	125		Ohio & Mississippi R. R.	Scottsville	3	177	531		Philadelphia, Wil. & Balt. R. R.	2 tracks	1	56	112	
Illinois Central	La Salle, Ill.	18	160	2880		"	West Fork	2	207	414		"	"	1	25	32	
Chicago & North Western	Clinton, Iowa	2	150	300		"	Big Sugar	1	116	116		"	Haute de Grace	7	(6-255)	1837	
Philadelphia, Wilmington & Balt.	Chester, Pa. 2 tracks	2	154	308		"	Little Wash.	1	33	33		"	Langley Creek	3	38	174	
"	" Draw. 2 tracks	2	127	254		"	Little Wash.	1	96	96		"	Milville Roadway Draw	1	130	130	
Reading R. R.	Flowertown	1	82	82		Grand Trunk Railway of Canada	St. Hyacinthe	3	(1-124)	372		"	Deep Gorge Viaduct	1	480	480	
Bridgeton, N. J.	Bridgeton, Draw	1	139	139		"	Black River	1	155	155		"	Wolf Creek	4	150	600	
North Pennsylvania R. R.	Saucon Creek	2	77	154		"	White River	2	(1-156)	224		Balt. & Ohio R. R., Valley R.R.Br.	"	3	50	150	
U. S. Arsenal	Rock Island, Ill. Highway	4	160	640		"	St. Francis	2	(1-78)	156		"	Washington Chain Bridge	8	(6-172)	1352	
Portland & Kennebec R. R.	Augusta, Me.	7	1-154	975		"	Magog	1	122	122		"	Waterville	4	(2-160)	613	
Connecticut Air Line R. R.	Viaduct	3	17	51		"	Massawippi	1	122	122		"	Biddeford Branch	5	(1-100)	599	
"	"	3	17	51		"	Conkoke	1	122	122		"	Phoenixville	2	(1-105)	202	
"	North Pond	1	120	120		"	Island Pond	1	114	114		"	Chupichaca Viaduct	3	(1-97)	262	
"	Batleyville	1	79	79		"	N. Stratford	1	124	124		"	Peru	3	(1-105)	366	
"	Saddle Hill	1	56	56		"	W. Paris	1	132	132		Philadelphia & Reading R. R.	Richmond St., Phila. 205 ft. wide	1	60	1344	
"	Pistol Factory	1	112	112		"	S. Park	1	138	138		"	2 tracks	7	(1-57)	285	
"	Lynan Viaduct. 2 tracks	2	224	448		"	McKee's Falls	1	156	156		Peru, Lima & Oraya R. R.	Rio Renca	1	204	1204	
"	Kapallo	1	2756	2756		"	N. Yarmouth	1	108	108		"	Capa Crossing	1	46	82	
Hudson River Bridge Co.	Albany. 2 tracks	15	7-273	3496		"	Boundary Line	1	75	75		"	Viaduct	1	129	129	
"	"	15	4-185	3496		"	Waterville	1	122	122		"	Anche Crossing	1	172	172	
Portland & Ogdensburg R. R.	Hiram, Me.	1	185	185		"	Northumberland	2	84	168		"	Viaduct	3	(1-83)	194	
Cambria Iron Co.	Johnstown	4	85	340		"	Little Androsogogit	3	(2-152)	406		"	"	3	(1-33)	368	
North Pennsylvania R. R.	Saucon Creek	5	(3-50)	248		"	Dummer No. 1	1	83	83		"	"	2	42	84	
Cheapeake & Ohio R. R.	New River	4	(2-47)	248		"	No. 2	2	76	150		Maine Central R. R.	Tonic	1	172	172	
Portland & Ogdensburg R. R.	Conway	2	(2-250)	500		"	Willow Brook	1	74	74		"	"	1	115	115	
Oatawasa R. R.	Viaduct	11	(2-75)	825		"	West Park	1	84	84		"	"	2	70	140	
Intercolonial Railway Co.	Miramichi	11	210	2310		"	Moose River	1	65	65		"	"	1	80	80	
Wheelock Bridge Co.	Restigouche	5	212	1060		"	Lewistown Canal. 3 tracks	1	65	195		"	"	1	58	58	
West Chester R. R.	Terre Haute. Highway	1	50	50		Philadelphia, Wil. & Balt. R. R.	Royal River at Yarmouth	1	125	125		"	"	1	30	30	
North Pennsylvania R. R.	Glen Mills	1	83	83		"	Balfay Park	2	(1-63)	94		"	"	1	61	61	
Camden & Amboy R. R.	Flightsdown	1	139	139		"	Moline, Ill.	1	163	259		"	"	1	115	115	
Alex. T. Stewart	Long Island	2	(1-54)	108		Central R. R. of New Jersey	Parampo. 3 tracks	1	90.3	259		"	"	1	140	140	
Cheapeake & Ohio R. R.	Greenbrier River	8	(4-104)	938		North Pennsylvania R. R.	Sellersville	6	(1-73)	228		"	"	1	80	80	
Maine Central R. R.	Brunswick, Me.	4	(2-182)	730		"	Tanghannock	1	102	102		"	"	1	58	58	
Cheapeake & Ohio R. R.	Rivanna Creek	1	97	97		"	Sheldrake Ferry	1	104	104		"	"	1	30	30	
A. Schofield	Manayunk. Highway	1	93	93		"	Trumansburg Viaduct	1	280	280		"	"	12	99	1188	
Ohio & Mississippi R. R.	Cochran	1	147	147		"	Seneca Canal	1	88	88		"	"	2	15	60	
"	"	2	(1-147)	310		Costa Rica Railway	Costa Rica	4	(1-68)	310		"	"	1	32	32	
"	Medora	2	(1-163)	310		"	"	4	(1-74)	310		"	"	2	(1-164)	310	
						City of Philadelphia	Girard Ave. 100 ft. wide. 7 trusses.	3	137	5190		"	"	5	(2-153)	317	
						Philadelphia, Wil. & Balt. R. R.	equal to 6 railroad tracks	2	137	130		"	"	3	(1-154)	370	
						"	Gray's Ferry. Roadway	1	150	150		"	"	1	(2-205)	513	
						"	2 tracks	1	142	284		"	"	1	55	55	
						"	"	1	109	218		"	"				

(7)

THE PHOENIX BRIDGE COMPANY.

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FOR WHOM BUILT.	LOCATION.	Spans.			FOR WHOM BUILT.	LOCATION.	Spans.			FOR WHOM BUILT.	LOCATION.	Spans.		
		No.	Length, Feet.	Total Length, Feet.			No.	Length, Feet.	Total Length, Feet.			No.	Length, Feet.	Total Length, Feet.
Great Western Railway of Canada.	St. George Viaduct.	8	50	400	Great Western Railway of Canada.	Delhi Viaduct.	1	(1-150)	283	Mexican Nat'l Construct'n Co.	East Sec., Toluca Div. (Bridges)	4	23	92
Quebec and Lake St. John Railway.	Jacques Cartier Bridge.	2	185	240	Philadelphia, Wil. & Balt. R. R.	Back River Bridge. 2 tracks.	37	14 to 22	1320	Gal'n's, H'b'g & San Antonio R. R.	Dev. Riv. P'd Cal. C'n, 1st C'g.	1	24	24
Sarat R. R., Brazil.	Nicoletto Bridge.	1	63	63	Quebec & Lake St. John Railway.	Fortout River.	1	60	60	Gal'n's, H'b'g & San Antonio R. R.	P'd Cal. C'n, 2d C'g. (Pecos Riv.)	1	53	53
Philadelphia & Reading R. R.	Manahoy Plane. 2 tracks.	1	16	32	Walsh Railway.	Over Lake St. John Discharge.	1	80	80	Gal'n's, H'b'g & San Antonio R. R.	At Station 11,992.	1	150	150
Great Western Railway of Canada.	Grand River at Cayuga.	4	93	372	Mexican Central Railway.	Vermilion River.	2	(1-160)	250	Gal'n's, H'b'g & San Antonio R. R.	At Station 11,939 and 11,988.	1	150	150
Baltimore & Harford Turnpike Co.	Gunpowder River.	1	122	122	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 11,968.	1	225	225
Great Western Railway of Canada.	Thames River, Ont.	2	80	160	Philadelphia, Wil. & Balt. R. R.	Over Lake St. John Discharge.	1	60	60	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,061.	1	260	260
	9 1/2 M. P., Cedar Creek.	2	46	92	Mexican Central Railway.	Haverhill Bridge. 2 tracks.	4	147	1176	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
	9th Ave., from 33d to 91st Sts. 3 Tr.	3	424	1272	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
	9th Ave., from 104th to 109th Sts., thence in a reversed curve to 8th Ave. and 111th St.; along 8th Ave. from 111th to 133d Sts. 2 tracks.	1	16704	16704	Mexican Central Railway.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
Indian Extension for Metropolitan Elevated Ry., N. Y.	Along 8th Ave. from 133d to 137th Sts. 3 tracks.	3	3168	3168	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
	Along 8th Avenue from 137th to 140th Sts. 4 tracks.	4	2392	2392	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
	Chatham Square, running up Division St. to Allen, to Houston. 2 tracks.	1	9842	9842	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
East Side, 2d Ave. Line for Manhattan Railway Co., N. Y.	Along 23d St. to 23d Ave. (proportioned to carry 3 trk.) 2 Trs.	2	12688	12688	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
	2d Ave. to 129th St., or Harlem River (proportioned to carry 4 tracks). 2 tracks.	1	55884	55884	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
	Between 59th and 67th Sts. and between 55th and 60th Sts.	1	1943	1943	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
Oscar von Nostitz.	San, Guatemala, C. A.	1	137	137	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
Hibernia Mine R. R., N. J.	Rockaway, N. J.	1	32	32	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
Great Western Railway of Canada.	Wortley St. Bridge, London, Ont.	1	32	32	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
Philadelphia & Reading R. R.	Nietown. 2 tracks.	1	145	290	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
Boston, Hoosac, Tan. & W's R. Ry.	Hoosac Falls Bridge. 2 tracks.	1	32	64	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
	" " Junction Bridge. 2 tracks.	1	36	72	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
Great Western Railway of Canada.	Dundas Bridge.	1	67	67	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
Walsh Railway.	Illinois River Bridge.	3	160	480	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
Great Western Railway of Canada.	Oakville Bridge, 17 1/2 M. P.	5	90	450	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
	Bozette Bridge, Toronto Div.	6	84	604	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
Great Western Railway of Canada.	North Alamo.	1	26	26	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
Hoosac Tun. & Troy & Gr'n'd Ry.	Public Road Bridge, 130 M. P.	1	22	22	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
Great Western Railway of Canada.	Braytonville, Hoosac River. 2 Tr.	4	76	608	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
Philadelphia, Wil. & Balt. R. Ry.	Toleno, O.	1	30	30	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
Walsh, St. Louis & Pacific R. Ry.	Toleno, O.	2	110	220	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
Hibernia Mine Railway, N. J.	Rockaway Bridge, N. J.	4	50	200	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
Calvarien & Santo Espirito R. Ry.	Cuba. Bridge No. 65.	1	27	27	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
	" " No. 66.	1	24	24	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
	" " No. 70.	1	13	13	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
	" " No. 18.	1	23	23	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
Hibernia Mine Railway, N. J.	Sandy Run Bridge No. 2. 2 tracks.	1	26	26	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
North Pennsylvania R. R.	129	2	120	120	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
Great Western Railway of Canada.	1st Crossing Fairchild's Creek.	1	Viaduct.	405	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
	" " " "	2d	Viaduct.	77	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
	" " " "	3d	Viaduct.	40	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
	" " " "	4th	Viaduct.	74	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
Harlem River Bridge.	Grand River Crossing.	3	80	240	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
	" " " "	2	187	74	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
	" " " "	1	300	600	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
	" " " "	2	100	400	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
	" " " "	1	69	178	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
	" " " "	1	60	120	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
	" " " "	5	58	290	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
	" " " "	1	62	124	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
	" " " "	1	61	122	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
	" " " "	1	62	124	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
	" " " "	1	62	124	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
	" " " "	1	62	124	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
	" " " "	1	62	124	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
	" " " "	1	62	124	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
	" " " "	1	62	124	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
	" " " "	1	62	124	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
	" " " "	1	62	124	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
	" " " "	1	62	124	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
	" " " "	1	62	124	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
	" " " "	1	62	124	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
	" " " "	1	62	124	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
	" " " "	1	62	124	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
	" " " "	1	62	124	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
	" " " "	1	62	124	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
	" " " "	1	62	124	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
	" " " "	1	62	124	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
	" " " "	1	62	124	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
	" " " "	1	62	124	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
	" " " "	1	62	124	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
	" " " "	1	62	124	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
	" " " "	1	62	124	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
	" " " "	1	62	124	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
	" " " "	1	62	124	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
	" " " "	1	62	124	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
	" " " "	1	62	124	Philadelphia, Wil. & Balt. R. R.	Bay View Road, 50 ft. wide.	3	30	90	Gal'n's, H'b'g & San Antonio R. R.	At Station 12,013.	1	300	300
	" " " "	1												

THE PHOENIX BRIDGE COMPANY.

FOR WHOM BUILT.				LOCATION.				FOR WHOM BUILT.				LOCATION.				FOR WHOM BUILT.				LOCATION.			
No.	Length, Feet.	Total Length, Feet.	Single Track.	No.	Length, Feet.	Total Length, Feet.	Single Track.	No.	Length, Feet.	Total Length, Feet.	Single Track.	No.	Length, Feet.	Total Length, Feet.	Single Track.	No.	Length, Feet.	Total Length, Feet.	Single Track.				
S. S. & L. R. R.	1	156	156	New York, West Shore & Buf. R. R.	1	34	68	Norfolk & Western R. R.	1	40	40	Little Otter Viaduct	5	60 1/2	60 1/2	716							
D. C. & M. R. R.	1	125	125	G. B. & A. L. R.	9	(8-30)	300	Devil's Gate, Colorado	1	160	160	Norfolk & Western R. R.	1	507 1/2	507 1/2	1	507 1/2	507 1/2	1				
Stony Creek	1	80	80	B. & C. S. W. R. R.	2	132	264	Bald Eagle Creek	3	50	150	Reelfoot & Canara R. R.	1	192	192	1	192	192	1				
Approaches to St. Charles Bridge	150	16	2080	Getysburg & Harrisburg R. R.	1	100	100	Fishing Creek	1	110	110	La compania de Almacenes de	1	1314	1314	1	1314	1314	1				
Central Pacific R. R.	1	224	224	"	1	110	110	"	1	110	110	de Porto de la Habana	1	900	900	1	900	900	1				
Great Western Railway of Canada	1	133	133	"	1	115	230	Port Richmond Branch, 2 tracks	1	207	207	Cay May Pier Co.	1	569	569	1	569	569	1				
"	1	133	133	"	1	110	110	Gay St. Bridge, Phoenixville	1	450	450	Norfolk & Western R. R.	1	123	123	1	123	123	1				
"	1	133	133	"	1	110	110	South Approach of Gay St. Bridge	1	138	138	Port Kennedy, Co. Fennway	4	140	140	4	140	140	4				
"	1	133	133	"	1	110	110	North	1	138	138	Mar. Cr'at' May, N. J. 30 ft. w'e	25	41	41	25	41	41	25				
"	1	133	133	"	1	110	110	James River, Va.	2	(1-18)	38	2d Crossing of New River	1	90	90	1	90	90	1				
"	1	133	133	"	1	110	110	New York, West Shore & Buf. R. R.	1	208	208	Jeannette Creek Bridge	3	41	41	3	41	41	3				
"	1	133	133	"	1	110	110	Central Pacific R. R.	1	38	76	Mohrlein Bridge	25	40	40	25	40	40	25				
"	1	133	133	"	1	110	110	Perth Amboy Br., Sun Pige. 2 Tr.	1	71	71	"	1	100	100	1	100	100	1				
"	1	133	133	"	1	110	110	16th St. & Indiana Ave.	2	21	42	"	1	278	278	1	278	278	1				
"	1	133	133	"	1	110	110	Phila. Ger'a & Chestnut Hill R. R.	2	21	42	G. W. Div. of G. T. R.	3	41	41	3	41	41	3				
"	1	133	133	"	1	110	110	Penna. Schuylkill Valley R. R.	1	350	350	Port Kennedy, Co. Fennway	4	140	140	4	140	140	4				
"	1	133	133	"	1	110	110	"	1	326	326	"	1	100	100	1	100	100	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	240	240	1	240	240	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	180	180	1	180	180	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	340	340	1	340	340	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	571	571	1	571	571	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	353	353	1	353	353	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	125	125	1	125	125	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	488	488	1	488	488	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	150	150	1	150	150	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	66	66	1	66	66	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	23	23	1	23	23	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	87	87	1	87	87	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	167	167	1	167	167	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	133	133	1	133	133	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	180	180	1	180	180	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	90	90	1	90	90	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	79	79	1	79	79	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	592	592	1	592	592	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	44	44	1	44	44	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	105	105	1	105	105	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	350	350	1	350	350	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	134	134	1	134	134	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	53	53	1	53	53	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	60	60	1	60	60	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	35	35	1	35	35	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	73	73	1	73	73	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	123	123	1	123	123	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	230	230	1	230	230	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	120	120	1	120	120	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	51	51	1	51	51	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	374	374	1	374	374	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	57	57	1	57	57	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	1942	1942	1	1942	1942	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	242	242	1	242	242	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	110	110	1	110	110	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	484	484	1	484	484	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	32	32	1	32	32	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	123	123	1	123	123	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	24	24	1	24	24	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	85	85	1	85	85	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	73	73	1	73	73	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	1143	1143	1	1143	1143	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	80	80	1	80	80	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	300	300	1	300	300	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	147	147	1	147	147	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	80	80	1	80	80	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	300	300	1	300	300	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	147	147	1	147	147	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	80	80	1	80	80	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	300	300	1	300	300	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	147	147	1	147	147	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	80	80	1	80	80	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	300	300	1	300	300	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	147	147	1	147	147	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	80	80	1	80	80	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	300	300	1	300	300	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	147	147	1	147	147	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	80	80	1	80	80	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	300	300	1	300	300	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	147	147	1	147	147	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	80	80	1	80	80	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	300	300	1	300	300	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	147	147	1	147	147	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	80	80	1	80	80	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	300	300	1	300	300	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	147	147	1	147	147	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	80	80	1	80	80	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	300	300	1	300	300	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	147	147	1	147	147	1				
"	1	133	133	"	1	110	110	"	1	30	30	"	1	80	80	1	80	80	1				
"	1	133	133	"	1	110	110	"															

THE PHOENIX BRIDGE COMPANY.

11

FOR WHOM BUILT.				LOCATION.				FOR WHOM BUILT.				LOCATION.			
No.	Length, Feet.	Spans.	Total Length, Feet.	No.	Length, Feet.	Spans.	Total Length, Feet.	No.	Length, Feet.	Spans.	Total Length, Feet.	No.	Length, Feet.	Spans.	Total Length, Feet.
Oreola Consolidation Mining Co.	233	6	233	290	Del. & Hudson Canal Co.	1	12	12	South'n Pacific Ry. Atlantic Syst.	1	97	97	Harvey's Canal. Draw	1	97
W. H. Crossman & Bro., N. Y.	103	5	30	103	Phila. & Read'g R. R., & S. Div.	1	115	230	Marshall, Del. Co., Pa.	1	38	38	N. Y. & Brooklyn Bridge Co.	1	38
Western Maryland R. R.	347	11	6-30 1/2	347	W. B. Wilkins, N. Y.	1	108	216	Parryville, Pa. 2 tracks.	1	21	21	N. Y. & Long Branch R. R.	1	16
J. J. Henderson, Plainfield, N. J.	81	2	81	231	East Tenn., Virginia & Ga. R. R.	2	150	300	London, Tenn.	2	32	32	1st Bridge North of Bingen	10	585
Town of Barrington, R. I.	124	1	124	124	W. B. Wilkins, N. Y.	2	29	58	Carolina Central R. R.	2	58	58	Broad River	3	140
Richmond & Danville R. R.	23	1	23	23	Phila. & Read'g R. R., N. P. Div.	1	23	23	Brooklyn Bridge	1	23	23	Sandy Run	5	240
Phila. & Erie R. R., Highw'y	81	1	81	81	Phila. & Read'g R. R., N. P. Div.	1	135	135	W. B. Henderson's Road, 2 Tr.	1	25	25	W. B. Henderson's Road, 2 Tr.	1	25
Phila. & Erie R. R., Highw'y	103	1	103	103	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216	Atlantic Coast Line	1	108
Dean & Westbrock, N. Y. Highw'y	99	2	99	198	Phila. & Read'g R. R., N. P. Div.	1	108	216	Shenandoah Valley R. R.	1	108	216	Gill St., Petersburg, Va.	1	118
Bartlett, Hayward & Co., Balt., Md. Highw'y	62 1/2	1	62 1/2	62 1/2	Phila. & Read'g R. R., N. P. Div.	1	108	216	Scioto Valley R. R.	1	108	216	Paint Ck., South of Chillicothe, O.	3	360
Houston & Texas Cent. R. R.	100	1	100	100	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216	1st Bridge Sth. of Hollerton, Pa.	2	131
Dean & Westbrock, N. Y. Highw'y	124	1	124	124	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216	South of Shelby, Pa.	2	105
Central Valley, Orange Co., N. Y.	30	1	30	30	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216	East Neck Island, Kent Co., Md.	2	160
Elberton, N. J.	19	2	19	38	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216	N. Y. City. Steel Girders, etc.	1	129
Baking Ridge, N. J.	52	1	52	52	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216	Iron Ore Creek, etc.	1	129
Over Schoykill Riv., Manayunk, Pa.	135 1/2	3	135 1/2	407	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216	Manayunk, Pa.	3	50
Over Lehigh Riv., Bethlehem, Pa.	146	3	146	407	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216	Engine Turn-Table	1	55
Millstone River, N. J.	49	1	49	49	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216	Canal at Rupert, Pa.	1	81
Cumb. Co., Pa.	48 1/2	2	48 1/2	97	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216	Cow-Pasture Bridge	2	246
Over Schoykill Riv., near Road	68	1	68	68	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phenicia, Pa.	2	40
Ing. Pa.	116	1	116	116	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216	1st Bridge North of Parkside, Pa.	1	39
Minooka, Lack. Co., Pa.	336	1	336	336	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216	Isle of Pass. Diplo. Gas Lt. Co. 14 trs.	1	59
Leopold, Pa.	125 1/2	3	125 1/2	376	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216	Memorith Co., N. J.	1	92
Upp. Freshold, Monmouth Co., N. J.	62	1	62	62	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216	Isle of Pass. Diplo. Gas Lt. Co. 14 trs.	1	59
Over Maiden Creek	164	1	164	164	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216	Swimming Riv., Mon. Co., N. J.	1	77
Goldboro, Lack. Co., Pa.	44	1	44	44	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216	Newman's Springs	1	182
Moore, Pa.	40	1	40	40	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216	Jersey City. Tr'n Shed. 25 tr's	1	140
Harvey's Creek, Luz. Co., Pa.	87	1	87	87	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216	North of Nicetown, Pa.	1	34
On Line Savannah Valley R. R.	149	1	149	149	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216	Camden, N. J.	1	72
Huntington Creek, Luz. Co., Pa.	58	1	58	58	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216	Wilmington & Northern R. R.	1	29
Phila. & Read'g R. R., & S. Div.	145 1/2	3	145 1/2	889	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216	Philadelphia, Pa.	1	52
Phila. & Read'g R. R., Highw'y	40	1	40	40	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216	B'tk Hawk Ck., Kethubg, Ill.	4	205
Atlantic City Ocean Pier Co.	1000	1000	1000	1000	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216	Beacon's Creek	3	50
Cheapeake & Ohio R. R.	86	1	86	86	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216	Louisville, Ky. Tr'n Shed. 14 tr's	1	151 1/2
Kethubg Bridge Co.	202	1	202	202	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216	Kent Co., Md.	1	32
W. H. Crossman & Bro., N. Y.	205	7	205	205	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216	Head House at Mahanoy Place	1	138
A. & H. Brock, Lebanon, Pa.	56	1	56	56	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216	Enderlin, Chestnut Hill, Pa.	1	85
H. P. Hepburn, Cleveland, O. Hy	150	6	150	150	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216	Mt. Quirauc. Observatory Tower	1	85
Dean & Westbrock, N. Y. Highw'y	42	1	42	42	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216	Duck Creek. Red Bank, O. 2 Tr.	2	142 1/2
Phila. & Read'g R. R., & S. Div.	149	1	149	149	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216	Dear Creek, Galveston, Ind.	1	65
Phila. & Read'g R. R., Highw'y	103	1	103	103	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216	Jersey Creek, Kansas City, Mo.	3	136
Atlantic City Ocean Pier Co.	1000	1000	1000	1000	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216	Crossing of Second Broad River	8	485
Cheapeake & Ohio R. R.	86	1	86	86	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216	Puzzle Creek	10	500
Kethubg Bridge Co.	202	1	202	202	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216	Charlottesville, ar. Van Emmons	1	124
W. H. Crossman & Bro., N. Y.	205	7	205	205	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216	Huston Sta.	1	85
A. & H. Brock, Lebanon, Pa.	56	1	56	56	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216	Strawberry Plains	9	405
H. P. Hepburn, Cleveland, O. Hy	150	6	150	150	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216	London, Tenn.	9	1239
Dean & Westbrock, N. Y. Highw'y	42	1	42	42	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216	Lick Creek	1	132
Phila. & Read'g R. R., & S. Div.	149	1	149	149	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216	North River	1	150
Phila. & Read'g R. R., Highw'y	103	1	103	103	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216	Cut-Off Bridge	1	40
Atlantic City Ocean Pier Co.	1000	1000	1000	1000	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216	Ohio Valley Construction Co.	3	550
Cheapeake & Ohio R. R.	86	1	86	86	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216	Parkensburg, W. Va.	3	550
Kethubg Bridge Co.	202	1	202	202	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216	Lee Creek	16	600
W. H. Crossman & Bro., N. Y.	205	7	205	205	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216	Little Sand	1	100
A. & H. Brock, Lebanon, Pa.	56	1	56	56	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216	Big Sand	1	125
H. P. Hepburn, Cleveland, O. Hy	150	6	150	150	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216	Big Mill	1	150
Dean & Westbrock, N. Y. Highw'y	42	1	42	42	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216	Little Mill	1	80
Phila. & Read'g R. R., & S. Div.	149	1	149	149	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216	Minneapolis City, 2 tracks	2	39
Phila. & Read'g R. R., Highw'y	103	1	103	103	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216	Vaduct, Louisville, Ky.	2	300
Atlantic City Ocean Pier Co.	1000	1000	1000	1000	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216	Silver Hook, R.I.	3	171
Cheapeake & Ohio R. R.	86	1	86	86	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216	Juragua Iron Co., Lim.	3	12
Kethubg Bridge Co.	202	1	202	202	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216	3 tracks	1	50
W. H. Crossman & Bro., N. Y.	205	7	205	205	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216			
A. & H. Brock, Lebanon, Pa.	56	1	56	56	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216			
H. P. Hepburn, Cleveland, O. Hy	150	6	150	150	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216			
Dean & Westbrock, N. Y. Highw'y	42	1	42	42	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216			
Phila. & Read'g R. R., & S. Div.	149	1	149	149	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216			
Phila. & Read'g R. R., Highw'y	103	1	103	103	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216			
Atlantic City Ocean Pier Co.	1000	1000	1000	1000	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216			
Cheapeake & Ohio R. R.	86	1	86	86	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216			
Kethubg Bridge Co.	202	1	202	202	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216			
W. H. Crossman & Bro., N. Y.	205	7	205	205	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216			
A. & H. Brock, Lebanon, Pa.	56	1	56	56	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N. P. Div.	1	108	216			
H. P. Hepburn, Cleveland, O. Hy	150	6	150	150	Phila. & Read'g R. R., N. P. Div.	1	108	216	Phila. & Read'g R. R., N.						

THE PHOENIX BRIDGE COMPANY.

FOR WHOM BUILT.				LOCATION.		Spans.		FOR WHOM BUILT.				LOCATION.		Spans.		FOR WHOM BUILT.				LOCATION.		Spans.	

THE PHOENIX BRIDGE COMPANY.

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FOR WHOM BUILT.	LOCATION.	Spans.		Total Length, Feet.	Total Length, Feet.	FOR WHOM BUILT.	LOCATION.	Spans.		Total Length, Feet.	Total Length, Feet.	FOR WHOM BUILT.	LOCATION.	Spans.		Total Length, Feet.	Total Length, Feet.
		No.	Length, Feet.					No.	Length, Feet.					No.	Length, Feet.		
Mexican Cent. R. R., Lim.		2	204	408		H. J. Davison, N.Y.	Roof Butler House, Memphis, Tenn. 13 trusses.....	1	42	108		Mayaville & Big Sandy R. R.	Greenup St., Covington, Ky. 2 Tr.	1	73	146	
Newport News & Mis. Val. R. R.	Olive Hill, Ky.	1	145	145		Dean & Westbrook, N.Y. Highw'y	Holmdel, N. J.	1	47	47		" " "	Scott " "	1	69	138	
Mayaville & Big Sandy R. R.	Powell St., Covington, Ky. 2 Tr.	1	147	294		" " " "	Bridgeport, Conn.	9	(2-42)	516		New River Bridge Co.	New River, at River View, W. Va.	3	(1-200)	750	
" " "	Main St., Dayton, Ky. 2 Tr.	1	170	340		" " " "	Draw.	1	(1-180)	180		Norfolk & Western R. R.	Blackwater Bridge.....	2	(1-200)	192	
" " "	Stevens St., Covington, Ky. 2 Tr.	1	134	268		South. Pacific R. R., Arizona Div.	Sienna Pass.....	1	(1-99)	180		" " "	Elk Creek " "	1	96	192	
Dean & Westbrook, N.Y. Highw'y	Patton " "	1	117	234		Houston & Texas Central R. R.	White Oak Bayon.....	3	(1-48)	438		" " "	New River " "	8	(2-50)	880	
" " "	Montfour Co., Pa.	1	73	73		" " " "	Walnut " "	1	(1-48)	129		Mayaville & Big Sandy R. R.	Terrence Ave., Newport, Ky. 2 Tr.	1	43½	87	
" " "	Jackson, N. H.	1	98	98		Bolivia Railway.....	East & West App. Lick'g Riv. 2 Tr.	2	82	328		Dean & Westbrook, N.Y. Highw'y	Galestan, Potter Co., Pa.	1	112	112	
Mayaville & Big Sandy R. R.	Montfour Co., Pa.	1	40	40		Mayaville & Big Sandy R. R.	West App. Licking Riv. 2 Tr.	1	71	142		C. R. R. of N. J.		1	57	57	
" " "	Wash. Ave., Bellevue, Ky.	1	50	50													
Dean & Westbrook, N.Y. Highw'y	Crompton, R. I.	2	(1-95)	127													
Mayaville & Big Sandy R. R.	" " "	1	(1-32)	50													
Mayaville & Big Sandy R. R.	" " "	1	(1-56)	50													
Cauca R. R.	" " "	2	(1-41)	97													

SUMMARY: Total number Single-Track Railway Spans..... 638,564 linear feet = 102 miles.
Total number of square feet of Iron Roofs..... 414,767 = 9.52 acres.
Total number of square feet of Ocean Piers..... 211,130 = 4.85 "



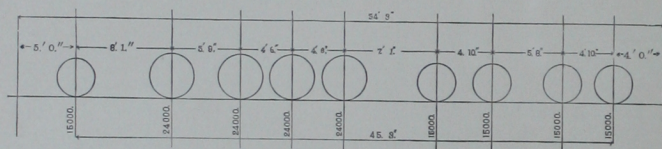
STANDARD SPECIFICATIONS OF THE PHENIX BRIDGE COMPANY

FOR

Railway and Highway Bridges and Viaducts.

Moving Load.

THE moving load for each track shall consist of two consolidation locomotives, with weights distributed according to the following diagram, followed by a train weighing 3000 pounds per lineal foot. In the case of double-track bridges, this moving load shall be taken as moving in either direction on either track:



Lateral Bracing.

The lateral bracing between the chords which do not carry the moving load shall be designed to resist a wind-pressure of 150 pounds per lineal foot of span.

The lateral bracing between the chords which carry the moving load shall be designed to resist a wind-load of 450 pounds per lineal foot of span, 300 of which shall be treated as a moving load.

Wind-Pressure.

In all viaducts and trestle towers the wind-pressure shall be taken as follows:

On the unloaded structure, 50 pounds per square foot of surface projected on the vertical plane through its axis.

On the loaded structure, 30 pounds per square foot of the same surface, in addition to an equal amount per square foot of train surface; the latter to be treated as a moving load. For determination of requisite anchorage, this computation shall be applied to a train of empty freight-cars, weighing 600 pounds per lineal foot of single track.

In all cases the projected surface of two trusses and two sides of towers, and one train, is to be taken as the surface of action of the wind. The overturning effect of the latter on both trusses and train shall be considered.

The weight of ties, guard-timbers, rails, spikes, etc., shall be taken at 400 pounds per lineal foot.

Ties, Guards, etc.

(14)

WORKING-STRESSES FOR IRON.

The greatest working-stresses in all wrought-iron tensile members of railway spans 150 feet in length and under shall be as follows:

Working-Stresses.

In counter-web members	8,000 pounds per square inch.
In long verticals	8,000 " " "
In main web and lower chord members (eye-bars)	10,000 " " "
In suspension-loops	7,000 " " "
In suspension-plates (net section)	7,000 " " "
In tension members of lateral and transverse bracing	15,000 " " "
In counter-rods and long verticals of lattice-girders (net section)	7,000 " " "
In lower chords and main tension members of lattice-girders (net section)	8,000 " " "
In bottom flange of plate-girders (net section)	8,000 " " "
In bottom flange of rolled beams	8,000 " " "
In angle-iron lateral ties (net section)	12,000 " " "

The greatest working-stresses in wrought-iron compression-members of spans 150 feet in length and under shall be the following, in which "P" is in pounds per square inch:

	Flat Ends.	Pin-Ends.
Phoenix Column	$P = \frac{8400}{1 + \frac{l^2}{50,000 r^2}}$	$P = \frac{8400}{1 + \frac{l^2}{30,000 r^2}}$
Latticed or Common Column	$P = \frac{8000}{1 + \frac{l^2}{40,000 r^2}}$	$P = \frac{7800}{1 + \frac{l^2}{30,000 r^2}}$
Angle-Iron Struts	$P = 9000 - 30 \frac{l}{r}$	$P = 9000 - 34 \frac{l}{r}$

"l" is the length of column, and "r" the radius of gyration of section, in direction of failure; both are to be taken in feet, or both in inches.

Upper chords shall be proportioned by the Flat-End formula.

A mean between Flat End and Pin-End results shall be used for one pin- and one flat end.

Upper Chords.
One Pin-End
and
One Flat End.

Lateral Struts. Lateral and transverse struts shall be designed by taking working-stresses equal to 1.4 those given by the preceding formulæ.

Spans over 150 Feet. In spans over 150 feet in length the greatest working tensile stresses per square inch of wrought-iron lower chord and end main web eye-bars shall be

$$8000 \left(1 + 0.9 \times \frac{\text{min. total stress}}{\text{max. total stress}} \right)$$

whenever this quantity exceeds 10,000.

In such spans the main web eye-bars nearest the centre shall be proportioned for 10,000 pounds per square inch; and the web eye-bars between the end and centre shall be found, by direct interpolation, between the above values.

The greatest working-stresses on the upper chords and end-posts of spans exceeding 150 feet in length shall be determined by increasing the results of the above column formulæ by the same proportion that the preceding process gives to the lower chord eye-bars of the same span. The proportionate increase of working-stresses for the intermediate posts shall be the same as that of the web eye-bars, meeting their upper ends in through spans and lower ends in deck spans.

Compression-Flanges of Plate-Girders. In the compression-flange of plate-girders and rolled beams the working-stress shall not exceed 8000 pounds per square inch of gross section.

Shearing-Stresses. The greatest shearing-stress due to combined dead and moving loads shall not exceed 7500 pounds per square inch, in any rivet or pin; or 10,000 pounds per square inch for wind-stresses; or 9000 pounds per square inch for wind-stresses, in combination with those due to moving load. A deduction of 20 per cent. from these values shall be made for field-driven rivets.

Bearing-Stresses. The greatest bearing-stress on any rivet or pin, due to combined dead and moving loads, shall be taken at 12,000 pounds per square inch of diametral surface; or 17,000 pounds per square inch of diametral surface for wind-stresses; or 15,000 pounds for wind-stresses, in combination with those due to moving load. A deduction of 20 per cent. from these values shall be made for field-driven rivets.

Bending-Stresses. The bending-stress of tension or compression on the extreme fibres of pins shall not exceed 15,000 pounds per square inch for combined dead and moving loads; or 20,000 pounds for wind-stresses; or 18,000 pounds for wind-stresses, combined with those due to moving load.

WORKING-STRESSES FOR STEEL.

Working-Stresses. The greatest allowed working-stresses in steel tension members, for spans of 200 feet in length and less, shall be as follows:

In counter-web members	10,500 pounds per square inch.
In long verticals	10,000 " " "
In all main web and lower chord eye-bars	13,200 " " "
In plate-hangers (net section)	9,000 " " "
In tension members of lateral and transverse bracing	19,000 " " "
In steel angle lateral ties (net section)	15,000 " " "

For spans over 200 feet in length, the greatest allowed working-stresses per square inch in lower chord and end main web eye-bars shall be taken at

$$10,000 \left(1 + \frac{\text{min. total stress}}{\text{max. total stress}} \right)$$

whenever this quantity exceeds 13,200.

The greatest allowable stress in the main web eye-bars nearest the centre of such spans shall be taken at 13,200 pounds per square inch; and those for the intermediate eye-bars shall be found, by direct interpolation, between the preceding values.

The greatest allowable working-stresses in steel-plate and lattice-girders and rolled beams shall be taken as follows:

Upper flange of plate-girders (gross section)	10,000 pounds per square inch.
Lower flange of plate-girders (net section)	10,000 " " "
In counters and long verticals of lattice-girders (net section)	9,000 " " "
In lower chords and main diagonals of lattice-girders (net section)	10,000 " " "
In bottom flanges of rolled beams	10,000 " " "
In top flanges of rolled beams	10,000 " " "

The greatest allowable working-stresses in steel-latticed or common columns, or steel Phoenix columns, for spans of 200 feet in length and less, shall be determined by taking four-thirds the values given by the formula for iron columns, on page 14.

The greatest allowable working-stresses for the same kind of columns, in spans over 200 feet in length, shall be found by increasing the values established by the preceding paragraph, by the same proportion, for the upper chords and end-posts, as the lower chord eye-bar-stresses are increased for the same length of spans.

The greatest allowable working-stresses in the columns nearest the centre shall remain unchanged; and those for the intermediate columns shall be found by direct interpolation.

The greatest working-stresses, in pounds per square inch, allowed in steel angle-struts, shall be as follows:

Flat-End Steel Angles	$P = 12,500 - 44 \frac{l}{r}$
Pin-End Steel Angles	$P = 12,500 - 50 \frac{l}{r}$

" l " is the length of the column, and " r " the radius of gyration of section, in direction of failure; both are to be taken in feet, or both in inches.

Upper chords shall be proportioned by the "Flat-End" formula, in all cases.

A mean between Flat-End and Pin-End results shall be used for one pin-end and one flat end.

Lateral and transverse struts shall be designed by taking working-stresses equal to 1.4 those given by the preceding formulæ, for both 200 feet pin-spans and angle-struts.

Spans over 200 Feet.

Plate- and Lattice-Girders.

Columns for Spans over 200 Feet and Less.

Columns in Spans over 200 Feet.

Angle-Struts.

Upper Chords.

One Pin-End and One Flat End.

Lateral Struts.

Shearing-Stresses.

The greatest shearing-stress on any rivet or pin, due to combined dead and moving loads, shall not exceed 10,000 pounds per square inch; or 13,000 pounds per square inch for wind-stresses; or 12,000 pounds for wind-stresses, in combination with those due to moving load. A deduction of 20 per cent. from these values shall be made for field-driven rivets.

Bearing-Stresses.

The greatest bearing-stress on any rivet or pin, due to combined dead and moving loads, shall be taken at 16,000 pounds per square inch of diametral surface; or 22,000 pounds per square inch of the same surface for wind-stresses; or 20,000 pounds for wind-stresses, in combination with those due to moving load. A deduction of 20 per cent. shall be made from these values for field-driven rivets.

Bending-Stresses.

The bending-stress of tension or compression on the extreme fibres of pins shall not exceed 20,000 pounds per square inch for combined dead and moving loads; or 26,000 pounds for wind-stresses, or 24,000 pounds for wind-stresses, combined with those due to moving loads.

GENERAL CLAUSES.

Combined Wind and Moving Loads.

In case wind-stresses combine with those due to dead and moving loads, no increase of section will be required, unless the wind-stresses exceed one-third the sum of those caused by the dead and moving loads, in which case provision will be made for the excess, at a unit-stress equal to four-thirds that allowed in the same member for the combined dead and moving loads; but in no case shall that unit-stress exceed 15,000 pounds for iron, or 18,500 pounds for steel for tension; or 10,500 pounds for iron, or 14,500 pounds for steel for compression; or 10,000 pounds for iron, or 12,000 pounds for steel for shear; or 19,000 pounds for iron, or 25,000 pounds for steel for extreme fibre stress in pin-bending.

Upper Chords of Lattice-Girders.

If the web-plate or plates, in the upper chord of lattice-girders, are not both supported by angles, and latticed, their working-stresses shall be determined by the formula for angle-struts; if, on the other hand, they are so supported, the formula for common columns shall be used, the gross section being taken in both cases. In all cases, the length " l " shall be taken, either between points of attachment of lateral bracing, or between panel-points, as may make " l " ÷ " r " the greatest possible.

Transverse Load Combined with direct Compression.

If the upper chord of a deck structure supports the ties (or its own weight) as a transverse load, such a member shall be designed to sustain the combined stresses arising under such circumstances of loading.

Alternate Stress.

All members (except lateral and transverse) sustaining alternate tension and compression shall be designed to carry each stress with six-tenths the smallest added thereto.

All structures shall be provided with complete and efficient systems of lateral and transverse bracing.

QUALITY OF MATERIALS.

WROUGHT-IRON.

Character and Finish.

1. All wrought-iron must be tough, ductile, fibrous, and of uniform quality for each class, straight, smooth, free from cinder pockets or injurious

flaws, buckles, blisters, or cracks. As the thickness of bars approaches the maximum that the rolls will produce, the same perfection of finish will not be required as in thinner ones.

2. No specific process or provision of manufacture will be demanded, provided the material fulfils the requirements of this specification.

3. The tensile strength, limit of elasticity, and ductility shall be determined from a standard test-piece, not less than one-quarter inch in thickness, cut from the full-size bar, and planed or turned parallel; if the cross-section is reduced, the tangent between shoulders shall be at least twelve times its shortest dimension, and the area of minimum cross-section in either case shall be not less than one-quarter of a square inch and not more than one square inch. Whenever practicable, two opposite sides of the piece are to be left as they come from the rolls, but the finish of opposite sides must be the same in this respect. A full-size bar, when not exceeding the above limitations, may be used as its own test-piece. In determining the ductility the elongation shall be measured, after breaking, on an original length the nearest multiple of a quarter inch to ten times the shortest dimension of the test-piece (in which length must occur the curve of reduction from stretch on both sides of the point of fracture), but in no case on a shorter length than five inches.

4. All iron to be used in the tensile members of open trusses, laterals, pins, and bolts, except plate-iron over eight inches wide and shaped-iron, must show by the standard test-pieces a tensile strength in pounds per square inch of

$$52,000 - \frac{7000 \times \text{area of original bar}}{\text{circumference of original bar}} \text{ (all in inches),}$$

with an elastic limit not less than one-half the strength given by this formula, and an elongation of 20 per cent.

5. Plate-iron 24 inches wide and under, and more than 8 inches wide, must show by the standard test-pieces a tensile strength of 48,000 pounds per square inch, with an elastic limit not less than 26,000 pounds per square inch, and an elongation of not less than 10 per cent. All plates over 24 inches in width must have a tensile strength not less than 46,000 pounds per square inch, with an elastic limit not less than 26,000 pounds per square inch. Plates from 24 inches to 36 inches in width must have an elongation of not less than 8 per cent., and those over 36 inches in width, 5 per cent.

6. All shaped iron and other iron not hereinbefore specified must show by the standard test-pieces a tensile strength in pounds per square inch of

$$50,000 - \frac{7000 \times \text{area of original bar}}{\text{circumference of original bar}}$$

with an elastic limit of not less than one-half the strength given by this formula, and an elongation of 15 per cent. for bars five-eighths of an inch and less in thickness, and of 12 per cent. for bars of greater thickness.

7. All plates, angles, etc., which are to be bent hot, in the manufacture must, in addition to the above requirements, be capable of bending sharply to a right angle at a working heat without sign of fracture.

Standard Test-Piece.

Tension-Iron for Open Trusses.

Plate-Iron.

Shaped-Iron.

Hot-Bending.

Rivet-Iron.	8. All rivet-iron must be tough and soft, and pieces of the full diameter of the rivet must be capable of bending cold until the sides are in close contact without sign of fracture on the convex side of the curve.
Bending Tests.	9. All iron specified in clause 4 must bend cold, 180 degrees, without sign of fracture, to a curve the inner radius of which equals the thickness of the piece tested.
	10. Specimens of full thickness cut from plate-iron, or from the flanges or webs of shaped-iron, must stand bending cold through 90 degrees, to a curve the inner radius of which is one and a half times its thickness, without sign of fracture.
Number of Test-Pieces.	11. For each contract four standard test-pieces and one additional for each 50,000 pounds of wrought-iron will, if required, be furnished and tested without charge, and if any additional tests are required by the purchaser, they will be made for him at the rate of \$5.00 each; or, if the Bridge Company desires additional tests, they shall be made at its own expense, under the supervision of the purchaser, the quality of the material to be determined by the result of all the tests in the manner set forth in the following clause.
	12. The respective requirements stated are for an average of the tests for each, and the lot of bars or plates from which samples were selected shall be accepted if the tests give such average results, but, if any test-piece gives results more than 4 per cent. below said requirements, the particular bar from which it was taken may be rejected, but such tests shall be included in making the average. If any test-piece has a manifest flaw, its test shall not be considered. For each bar thus giving results more than 4 per cent. below the requirements tests from two additional bars shall be furnished by the Bridge Company without charge, and if in a total of not more than ten tests two bars (or, for a larger number of tests, a proportionately greater number of bars) show results more than 4 per cent. below the requirements, it shall be cause for rejecting the lot from which the sample bars were taken. Such lots shall not exceed 20 tons in weight, and bars of a single pattern, plates rolled in universal mill or in grooves, and sheared plates shall each constitute a separate lot.
Time of Inspection.	13. The inspection and tests of the material must be made promptly on its being rolled, and the quality determined before it leaves the rolling-mill. All necessary facilities for this purpose shall be afforded by the manufacturer; but if the inspector is not present to make the necessary tests, after due notice given him, then the Bridge Company shall proceed to make such number of tests on the iron then being rolled as may have been agreed upon, or, in the absence of any special agreement, the number provided for in clause 11, and the quality of such material shall be determined thereby.
Variation of Weight.	14. A variation in cross-section or weight of rolled material of more than 2½ per cent. from that specified may be cause for rejection.

STEEL.

15. No specific process or provision of manufacture will be demanded,

provided the material fulfils the requirements of this specification. The ultimate tensile resistance of the steel to be used in tension shall be 62,500 pounds per square inch, and the ultimate tensile resistance of the steel to be used in compression shall be 68,000 pounds per square inch.

16. From one ingot of each cast two round sample bars not less than three-quarters of an inch in diameter, and having a length not less than twelve diameters between jaws of testing-machine, shall be furnished and tested by the manufacturer without charge. These bars are to be truly round, and shall be finished at a uniform heat, and arranged to cool uniformly, and from these test-pieces alone the quality of the material shall be determined.

17. All the above-described test-bars must have a tensile strength within 4000 pounds per square inch of that specified, an elastic limit not less than one-half of the tensile strength of the test-bar, a percentage of elongation not less than 1,200,000 ÷ the tensile strength in pounds per square inch, and a percentage of reduction of area not less than 2,400,000 ÷ the tensile strength in pounds per square inch. In determining the ductility the elongation shall be measured after breaking on an original length of ten times the shortest dimension of the test-piece, in which length must occur the curve of reduction from stretch on both sides of the point of fracture.

18. Finished bars must be free from injurious flaws or cracks, and must have a workmanlike finish, and round or square test-pieces cut therefrom when pulled asunder shall have reduction of area at the point of fracture as above specified.

19. For each contract four such tests, respectively, for reduction of area and for bending, and one additional of each for each 50,000 pounds of steel, will, if required, be made without charge; and if the purchaser is not satisfied that the reduction of area-test correctly indicates the effect of the heating and rolling, such additional tests for tensile strength, limit of elasticity, and ductility as he may desire will be made for him on test-pieces conforming to the provisions of clause 3, at the rate of \$5.00 each; or, if the Bridge Company desires additional tests, it may make them at its own expense, under the supervision of the purchaser, the quality of the material to be determined by the result of all the tests in the manner set forth in the following clause.

20. Except for tensile strength, the respective requirements stated are for an average of the tests for each, and the lot of bars or plates from which samples were selected shall be accepted if the tests give such average results, but if any test-piece gives results more than 4 per cent. below said requirements, the particular bar from which it was taken may be rejected, but such tests shall be included in making the average. If any test-piece has a manifest flaw, its test shall not be considered. For each bar thus giving results more than 4 per cent. below the requirements tests from two additional bars shall be furnished by the Bridge Company without charge, and if in a total of not more than ten tests two bars (or, for a larger number of tests, a proportionately greater number of bars) show results more than 4 per cent. below the requirements, it shall be cause for rejecting the lot from which the sample

Test Bars.

Tensile Tests.

Finish and Reduction of Area on Finished Bars.

Number of Test-Pieces.

	bars were taken. Such lots shall not exceed 20 tons in weight, and bars of a single pattern, plates rolled in universal mill or in grooves, and sheared plates shall each constitute a separate lot.	
Rivet-Steel.	21. Rivet-steel shall have a specified tensile strength of 60,000 pounds per square inch, and test-bars must have a tensile strength within 4000 pounds per square inch of that specified, and an elastic limit, elongation, and reduction of area at the point of fracture, as stated in clause 17, and be capable of bending double, flat, without sign of fracture on the convex surface of the bend.	
Time of Inspection.	22. The inspection and tests of the material will be made promptly on its being rolled, and the quality determined before it leaves the rolling-mill. All necessary facilities for this purpose shall be afforded by the manufacturer; but if the inspector is not present to make the necessary tests, after due notice given to him, then the Bridge Company shall proceed to make such number of tests on the steel then being rolled as may have been agreed upon, or, in the absence of any special agreement, the number provided for in clauses 16 or 19, and the quality of such material shall be determined thereby.	
Variation of Weights.	23. A variation in cross-section or weight of rolled material of more than 2½ per cent. from that specified may be cause for rejection.	
	CAST-IRON.	
	24. Except where chilled-iron is specified, all castings shall be of tough gray iron, free from injurious cold-shuts or blow-holes, true to pattern and of a workmanlike finish. Sample pieces one inch square, cast from the same heat of metal in sand-moulds, shall be capable of sustaining, on a clear span of 4 feet 6 inches, a central load of 500 pounds when tested in the rough bar.	
	WORKMANSHIP.	
Inspection.	25. Inspection of the work shall be made as it progresses, and at as early a period as the nature of the work permits.	
	26. All workmanship must be first-class. All abutting surfaces of compression-members, except flanges of plate-girders where the joints are fully spliced, must be planed or turned to even bearings, so they shall be in such contact throughout as may be obtained by such means. All finished surfaces must be protected by white lead and tallow.	
	27. The rivet-holes for splice-plates of abutting members shall be so accurately spaced that when the members are brought into position the holes shall be truly opposite before the rivets are driven.	
	28. When members are connected by bolts which transmit shearing-strains, the holes must be reamed parallel, and the bolts turned to a driving-fit.	
	29. Rollers must be finished perfectly round and roller-beds planed.	
Rivets.	30. Rivets must completely fill the holes, have full heads concentric with the rivet, of a height not less than .6 the diameter of the rivet (unless otherwise shown on plans), and in full contact with the surface, or to be countersunk when so required, and machine-driven wherever practicable.	
	31. Built members must, when finished, be true and free from twists, kinks, buckles, or open joints between the component pieces.	
	32. All pin-holes must be accurately bored at right angles to the axis of the members, unless otherwise shown in the drawings, and in pieces not adjustable for length no variation of more than one-thirty-second of an inch will be allowed in the length between centres of pin-holes; the diameter of the pin-holes shall not exceed that of the pins by more than one-thirty-second inch, nor by more than one-fiftieth inch for pins under three and one-half inches diameter. Eye-bars must be straight before boring; the holes must be in the centre of the heads, and on the centre line of the bars. Whenever links are to be packed more than one-eighth of an inch to the foot of their length out of parallel with the axis of the structure, they must be bent with a gentle curve until the head stands at right angles to the pin in their intended position before being bored. All links belonging to the same panel, when placed in a pile, must allow the pin at each end to pass through at the same time without forcing. No welds will be allowed in the body of the bar of eye-bars, laterals, or counters, except to form the loops of laterals, counters, and sway-rods; eyes of laterals, stirrups, sway-rods, and counters must be bored; pins and lateral bolts must be finished perfectly round and straight, and the party contracting to erect the work must provide pilot-nuts where necessary to preserve the threads while the pins are being driven. Thimbles or washers must be used whenever required to fill the vacant spaces on pins or bolts.	Eye-bars and Pin-holes.
	33. To determine the strength of the eyes, full-size eye-bars or rods with eyes may be tested to destruction, provided notice is given in advance of the number and size required for this purpose, so that the material can be rolled at the same time as that required for the structure, and any lot of iron bars from which full-size samples are tested shall be accepted:	Pilot-Nuts.
	1st, if not more than one-third the bars tested break in the eye; or	Tests of Eyes on Full-Size Bars.
	2d, if more than one-third do break in the eye, and the average of the tests of those which so break shows a tensile strength in pounds per square inch of original bar, given by the formula:	
	$52,000 - \frac{7000 \times \text{area of original bar}}{\text{circumference of original bar}} - 500 \times \text{width of bar (all in inches)},$	
	and not more than one-half of those which break in the eye fail at more than five per cent. below the strength given by the formula.	
	Any lot of steel bars from which full-size samples are tested shall be accepted if the average of the tests shows a strength per square inch of original bar, in those which break in the eye, within 4000 pounds of that specified as in clause 17; but if one-half the full-size samples break in the eye, it shall be cause for rejecting the lot from which the sample bars were taken. All full-size sample bars which break in the eye at less than the strength here specified shall be at the expense of the Bridge Company, unless it shall have made objection in writing to the form or dimension of the heads before making the eye-bars. All others shall be at the expense of the purchaser. If the Bridge Company desires additional tests, they shall be made	

at its own expense, under the supervision of the purchaser, the acceptance of the bars to be determined by the result of all the tests in the manner above set forth. A variation from the specified dimensions of the heads will be allowed, in thickness of one-thirty-second inch below and one-sixteenth above that specified, and in diameter of one-fourth inch in either direction.

Punching and
Reaming.

34. In iron-work the diameter of the punch shall not exceed by more than one-sixteenth inch the diameter of the rivets to be used. Rivet-holes must be accurately spaced; the use of drift-pins will be allowed only for bringing together the several parts forming a member, and they must not be driven with such force as to distort the metal about the holes; if the hole must be enlarged to admit the rivet, it must be reamed; all rivet-holes in steel work, if punched, shall be made with a punch one-eighth inch in diameter less than the diameter of the rivet intended to be used, and shall be reamed to a diameter one-sixteenth inch greater than the rivet.

Annealing.

35. In all cases where a steel-piece in which the full strength is required has been partially heated the whole piece must be subsequently annealed. All bends in steel must be made cold, or, if the degree of curvature is so great as to require heating, the whole piece must be subsequently annealed.

36. All surfaces inaccessible after assembling must be well painted or oiled before the parts are assembled.

Painting.

37. The decision of the engineer shall control as to the interpretation of drawings and specifications during the execution of work thereunder, but this shall not deprive the Bridge Company of its right to redress, after the completion of the work, for an improper decision.

HIGHWAY BRIDGES.

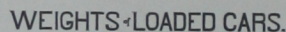
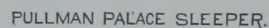
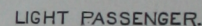
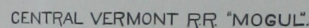
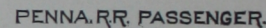
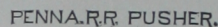
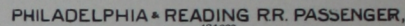
Highway bridges shall be proportioned to carry their own weight, added to 80 pounds per square foot of clear roadway and sidewalk, as moving load for spans of less than 125 feet, or 60 pounds per square foot for spans over 125 feet. In all cases the floor system shall be designed for a moving load of 100 pounds per square foot of clear roadway or sidewalk.

The greatest allowable stresses of the various kinds shall be determined by increasing those for railway structures to the extent of 20 per cent.

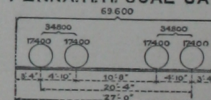
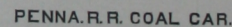
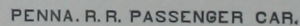
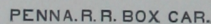
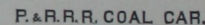
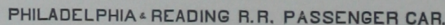
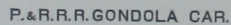
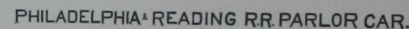
The general excellence of the work and material shall fully equal that required for railway structures.



ACTUAL WEIGHTS OF ENGINES & TENDERS.



WEIGHTS OF LOADED CARS.



PHOENIXVILLE BRIDGE WORKS.

THE Works of the Phoenix Iron Company, at Phoenixville, Pa., are conveniently situated with respect to the ore-beds and coal-fields of the eastern part of that State, and within easy reach of the markets of the country by means of the admirable systems of transportation afforded by the Philadelphia and Reading and the Pennsylvania Railroads. Not only because of the quantity and high quality of their product have these Works won a world-wide reputation, but also by reason of the large extent and the well-planned arrangement of the many furnaces, mills, and shops that constitute the plant of the Company. Beginning on a small scale in the year 1790, these works were materially enlarged in 1827. In 1842 very extensive additions were made in the shape of a complete puddling-mill with six single furnaces, a Burden rotary squeezer, and a train of rolls, this being the first establishment in the Schuylkill Valley to begin the puddling of iron on a large scale. In 1845 two blast-furnaces 15 by 59 feet were built, and in 1846 a third blast-furnace 15 by 59 feet was put up. These furnaces are still in operation, but have been very greatly improved by the addition of such modifications as have been brought forward from time to time and approved by the usage of the best iron-workers. In 1846 a large mill for manufacturing railway iron was erected and equipped with a complete set of furnaces, engines, and rolls requisite for the production of such material.

In this mill was rolled much of the railway iron that was used in the construction of the pioneer railroads of this country, and its products were well known in every State of the Union. In 1855 the ownership of the works was merged into a stock company under the title of "The Phoenix Iron Company," and the manufacture of beams, channels, tees, and a variety of shapes of iron was begun. The capacity of their shops and foundry having been enlarged, they entered upon the construction of bridges, roofs, and other varieties of structural iron-work, and this department of their business has steadily increased in importance since its establishment. During the civil war many hundred wrought-iron field-guns were made at these works, as well as large quantities of material for ordnance service and naval stores.

In 1862 the Phoenix column was introduced to the market, and in 1866 the manufacture of eye-bars forged by hydraulic pressure for bridge-links was begun.

These two important factors in the construction of bridge-work, in furnishing engineers with their material arranged in the most perfect forms for resisting the strains of compression and tension, have performed signal service in developing the American type of bridge, and have made practicable the rapid and economical manufacture of engi-

neering structures adapted to a great variety of purposes. In 1870 the works occupied an area of about 30 acres, but so steady had been the demand for their product, and so wide was the field for its employment, that it was then considered advisable to make provision for such enlargement of their capacity as would enable them to meet the requirements of their business in a more satisfactory manner. A large building, covering about 6½ acres under a single roof, was erected, and a complete outfit of gas producers, regenerative furnaces, compound engines, and trains of rolls planned for its equipment in the most thorough manner. This building served as a model for the architects of the Centennial Exhibition buildings, and is admirably adapted to the special requirements of a large rolling-mill. It is 928 feet long, 288 feet wide, and 30 feet high to the square. It is built almost wholly of iron and glass. Two long parallel sheds connected by four spacious transepts, and enclosing three interior courts, will convey, in brief description, some idea of the general plan.

Two views of the Works are presented in this album, from photographs, which give some idea of the general arrangement of the plant, but necessarily omit much, and but inadequately represent its magnitude. One of them shows, in part, the new rolling-mills. Back of this building is that of the gas-producers, 60 feet wide, running the length of the main building and separated from it by a passage-way of 150 feet. The second view represents the blast-furnaces, puddling- and old rolling-mills. On the opposite side of the creek, in front of them, but not shown, are the various shops, foundry, and other buildings used in the manufacture of bridges.

The drains, water-pipes, steam-pipes, and gas-passages form an intricate system under the iron floor that is quite hidden from the visitor, but, like the circulation of a living organism, a system most essential to the vitality and action of the body that is dependent upon it. The recent adoption of gaseous fuel has enabled manufacturers to regulate much more satisfactorily the quality of their iron by keeping it clean and free from ashes or dust during the process of heating, as well as by giving a thorough control of the temperature desired in the furnace, and these advantages are obtained in this mill by the use of all of the appliances yet devised for the purpose.

From these furnaces the iron is rolled into the various forms required in the construction of buildings, bridges, and ships by passing it between rolls having in them grooves of the form it is desired to give to the bars. From the mills such bars as are to be further worked up into the construction of bridges or buildings are taken to the machine-shops.

These buildings, the largest covering not less than two acres of ground, contain

the various machines and tools by which the iron is planed, turned, drilled, and handled with expedition and accuracy. Steam-riveting and air-riveting machines replace the din of the hand-hammers and sledges of a decade ago, and do more than double the amount of work almost noiselessly. In an adjoining building special attention is given to the riveting of the Phoenix columns, large numbers of which in a great variety of sizes can be very quickly produced by means of the tools specially adapted for the purpose. The heavy links for bridge eye-bars are forged by hydraulic pressure in another shop which is set apart for this particular work. The heads upon these bars are made by a process that insures the development of the full strength of the bar when under strain in a structure. The end of the bar having been heated to a white heat is upset by pressure between dies, and then shaped by reheating and further pressure into the desired form. After cooling and trimming, the pin-holes are bored, both holes at one operation, thus insuring an accuracy in the distances from centre to centre of holes that is essential in the manufacture of work of this character. Powerful testing-machines stand ready to prove by actual pull the strength of the bars thus made, and to enable inspectors to determine the elasticity and ductility, as well as the ultimate strength of the material called for by their specifications. Adjoining the hydraulic forge a hammer-shop, with a 6-ton steam-hammer and gas-heated furnace, has recently been put up, and will greatly add to the power and capacity of the forge. Here can be handled and made any parts of a bridge requiring heavy and accurate die-forging, and the use of gas for heating the material will give the same advantages of clean work and control of temperature that is obtained in the mill-furnaces.

The foundry of the Company is a spacious stone building with iron roof-frame and ample light from all sides. It is served with steam-cranes and all modern appliances for producing the best material at the lowest cost, and is kept constantly busy in turning out the various forms and shapes of iron that the ingenuity of the millwright delights to design and the skill of the workman takes pleasure in constructing.

The old frame building that was used for foundry purposes was destroyed by fire April 23, 1882, and the first casting made in the new foundry was in the afternoon of June 16, 1882. The numerous and valuable patterns belonging to the works are stored in a brick building put up expressly for the purpose of affording protection against the risk of their destruction by fire. It is four stories high and is lighted from a skylight in the roof by a central shaft, about which the shelves and passages are arranged in such a way as to afford the greatest amount of storage room with easy access to the patterns and ample light in every corner. The distribution of material from the mills to the shops and about the yards is effected by a system of narrow-gauge railway that ramifies throughout the yards and reaches every part of the works. Four locomotives are constantly employed in the service of this system of distribution, and have with great economy taken the place of the many mules and horses that formerly attended to this very necessary duty.

A large stock of beams and shape-iron of every variety of size and weight is kept on hand for supplying promptly orders for such material, and telegraphic orders from New York, Boston, Chicago, or Baltimore can in this way be filled with accuracy and despatch, and the iron loaded and shipped in a few hours after the receipt of specifications.

For supplying the many boilers, for cooling the furnace sides, for the service of the condensers, and for a great many other purposes, an abundant supply of excellent water is obtained from the Saukanac, or French Creek, along the valley of which the works extend for nearly a mile. A Worthington pump of 2½ million gallons capacity raises this water to a storage reservoir on the hill-side, whence it is distributed by a system of mains and service pipes to all parts of the newer works.

Thus the whole establishment is arranged for the production of iron of high quality on a large scale in a great variety of shapes by means of the most modern and improved appliances, and claims to occupy a place among the foremost American mills.



DESCRIPTION OF DESIGNS.

DESIGN "A."

THE general style of girder shown in this design is well adapted to spans under 18 or 20 feet. It is composed of two eye-beams, 15 inches deep in the present case, weighing 200 pounds to the yard. These beams are thoroughly braced in two panels, so as to secure perfect lateral stability.

The lateral struts are 6-inch eye-beams, and the ties are rods $1\frac{1}{2}$ inch in diameter.

This simple structure is specially adapted to locations in which the head-room is very limited.

The plate represents a girder placed on the line of the Portland and Rochester Railroad, at Portland, Me.

DESIGN "B."

This design shows the adaptation of our deck plate-girder system to a span of about 40 feet. In the vicinity of the ends the chords are each composed of a pair of angles, which are reinforced for somewhat more than the central half of the span by a heavy plate. As there is only one cover-plate, it may be depended upon to perform its functions with the greatest efficiency.

The stiffness of the intermediate portion of the web is secured by pairs of angles (one angle on each side of web) riveted at sufficiently frequent intervals. As the ties are placed on the top chords, the ends of the girders are subjected to very severe shocks and consequent fatigue. This is amply provided against by extra heavy vertical end-stiffeners riveted over fillers reaching from upper to lower chord-angles.

Transverse stiffness is secured by latticed struts of equal depth of the girders, which take hold of the angle-stiffener throughout the entire depth of the main girder. These transverse struts also serve as the compression-members of the lateral system, the latter being completed by the ties as shown. The most thorough lateral and transverse stiffness is thus secured, and the girders enabled to sustain in the most efficient manner that severe use under rapidly-passing heavy loads to which all short spans are unavoidably subject.

This particular structure was built for the Seaboard and Roanoke Railroad, and forms a part of the "Meherrin Bridge."

These plate-girders may be advantageously used under ordinary circumstances for spans running from 20 to 50 feet, although they have been constructed for spans of about 70 feet.

DESIGN "C."

Our plate-girder construction of the "through" type is shown in this design. It represents a 65-foot 3-inch over all single-track span on the line of the Georgia, Midland and Gulf Railroad, over Mulberry Creek.

The girders are 6 feet deep, and placed 14 feet 0 inches apart centres. At every second stiffener (in this case it happens to be at every web-joint) a cross floor-beam is riveted to the girders, and between these beams are riveted two lines of longitudinal iron stringers, placed eight feet apart centres. There is thus formed a floor equal to the most exacting requirements of any traffic at any possible speed.

End angle struts and lateral rods, as shown, complete the lower lateral system. Heavy plate and angle gussets reach from each end of each floor-beam to the upper flanges of each girder, and are riveted to both beams and girders. These gussets hold the girders rigidly in perfect alignment.

DESIGN "D."

The general character of our deck lattice-girders is well illustrated by this plate, which represents the 60-foot span of the Kinzua Viaduct. The upper and lower chords are alike, and are composed of two angles and a deep web-plate extending throughout the length of the span, reinforced over about the central half by a cover-plate. A sufficient depth of web-plate in the chords was taken to properly resist the bending action of the moving load in combination with the direct compression, as well as to secure sufficient bearing surface for the rivets uniting the web members to the chords.

All the web-braces are arranged in pairs, so as to take hold of both sides of the chord-plate, thus securing double shear in the rivets, and completely avoiding all twisting of the chords. Both the rivet shear and the bearing capacity of rivets against the plate and angles are carefully considered in all our riveted work; and when, as in the present instance, the ties rest directly on the chord, the latter is designed to resist the combined stresses arising under such circumstances.

By our system of construction we are enabled to make the centre lines of stress of members meeting at one place intersect as nearly as possible in one point, thus essentially avoiding those secondary stresses which frequently constitute such an objectionable feature in riveted work.

The vertical end-posts are made very heavy, as they are exposed to very severe duty.

The transverse and lateral systems of bracing are of heavy angle-iron and in short panels, and so attached to the chords as to develop the full resistance of cross-section in the most direct and effective manner.

At and near the centre of the span, where the web members take both kinds of stress, both bars and angles are provided, the former to take the tension and the latter to resist the compression.

All intersections of web members are riveted, in order to shorten the struts and give general stiffness.

DESIGN "E."

This design shows a single track through lattice girder span, on the line of the Maysville and Big Sandy Railroad, in the city of Maysville, Ky., and is typical of our usual through lattice structure. The girders are 6 feet deep and 55 feet in length over all, and in this case are placed 14 feet apart centres.

A floor system of wrought-iron cross floor-beams, and longitudinal stringers riveted between them, carries each track, and meets the most severe requirements of any traffic.

A system of lateral bracing in the plane of the floor, and heavy angle knee-braces reaching from the floor-beams to the upper chords of the girders, secure perfect lateral stability in the most complete and satisfactory manner.

There are two systems of triangulation in each girder, between which the loads carried are equally divided. The floor-beams are placed two panel lengths apart, and they are supported at the intersection of the web members of the two systems of bracing, so that the division of all loads is necessarily exactly equal between those systems. There is thus absolutely no indetermination of stresses, and every feature of the design is characterized by a maximum of economy and excellence.

DESIGN "F."

Our type of ordinary through bridge for railway traffic is well exemplified by these trusses of 120-foot span, built for the Norfolk and Western Railroad, and forming a part of the bridge at Reed Island crossing. In each span there are six panels of 20 feet, and the trusses are 21 feet deep. The chief characteristics are the single system of triangulation with long panels, and consequently small number of parts, great simplicity of details, and the use of "Phoenix" columns as compression-members. The long panels reduce the number of parts, and hence the tendency to vibration, to a minimum, while the economy of inclined end-posts is considerably increased.

The top and bottom lateral bracing is designed for a total wind-pressure of 550 pounds per lineal foot, in addition to which there are heavy transverse knee-braces. The lateral stability is still further materially increased in an incidental manner, both by the floor-beams being drawn tightly up against and into recesses at the bottom of the posts, and by the ties and struts between the stringers, which really constitute an independent lateral system. These latter give the requisite lateral stiffness to the long track-stringers. Both the truss and floor system are thus seen to be peculiarly well adapted to a heavy and rapidly-moving traffic.

DESIGN "G."

The design taken to illustrate a type of all wrought-iron structure best adapted to lengths below what may be termed "long spans," is one of two single-track spans on the

line of the Cincinnati, Washington and Baltimore Railroad, over the Muskingum River, at Marietta, Ohio.

The truss is 187 feet 6 inches long between centres of end-pins, and 27 feet deep between centres of chords. There are nine panels of 20 feet 10 inches each. This length of panel, in combination with the depth used, gives to the single system of triangulation a pleasing appearance, and at the same time secures for it all the advantages of economy and stiffness arising from concentration of metal in few members.

Heavy upper and lower lateral and transverse systems of bracing give complete rigidity in those directions. The stringers are placed between the floor-beams and riveted to their webs, while the beams themselves are suspended from the lower chord-pins. The horizontal bracing between the stringers aids the lower lateral bracing in giving additional stiffness to the floor, all of which, combined with the method of securing the stringers firmly between the floor-beams, adapts the structure to the requirements of the heaviest traffic at high speeds, at the same time guarding the bridge against serious damage in case of accidents to moving trains.

The compression-members of this span are of the open-column type, composed of plates and built channels of plates and angles, all of wrought-iron.

DESIGN "H."

The adaptation of the Phoenix column construction to a very heavy structure is shown by this span of a two-truss double-track railway bridge, with a span of 264 feet and $\frac{1}{2}$ of an inch from centre to centre of end-pins. It forms one span of the Rondout Bridge, on the line of the New York, West Shore and Buffalo Railway; the complete structure will receive a full description on another page.

As the total load is divided between two trusses only, the members of each are unusually heavy; consequently, the economic depth of truss takes a comparatively high value.

The depth of 45 feet fixed upon in the design involves the incidental but important advantage in such a length of span of a small deflection and correspondingly increased stiffness.

Heavy upper and lower lateral systems of bracing are provided, in connection with transverse bracing, in the vertical planes of each pair of opposite panel-points, besides portals of unusual stiffness. The general stability of the bridge is still further increased by bracing the upper half of the third panel from either end in each truss, and connecting the lower transverse bracing-points of all the posts.

There are fifteen panels of 17 feet $7\frac{1}{2}$ inches each.

The converging of a large number of eye-bars at the upper extremity of the end-post presented a problem which is effectually solved in a very simple manner by a massive plate hung on the end-pin in the manner shown.

The transverse floor-beams are necessarily of unusual depth, and their lower chords are held rigidly in place by tie-rods reaching from each pin to the lower extremity of each adjacent pair of hanger-loops.

In the centre panel of each truss there are ten eye-bars, giving rise, unless properly designed and arranged, to excessive pin-bending. As in all our designs, the eye-bars and pins were here so proportioned that the extreme fibre-stress does not exceed 15,000 pounds per square inch.

DESIGN "I."

The disposition of metal in spans of about 300 feet and over, in such a manner as best to secure economy and simplicity, and at the same time fulfil the requirements of the most advanced structural design, is a matter requiring serious consideration. A careful examination of this design will show that it possesses every feature requisite to meet the demands of the case. The increased depth at the centre of the span, with the gradual decrease towards the ends, affords the proportional resistance to the comparatively small bending moment near the ends, and the maximum at the centre, with a much more nearly uniform chord section than would be attained with parallel chords. The same feature materially shortens the heavy web members near and at the ends of the span.

The secondary trussing in the double panels at and near the centre forms the means of attaining very important results in the high trusses necessary for long spans, by giving to the main ties an economical inclination, in connection with a desirable length of panel. The number of main truss members is thus reduced to a minimum, and their increased size and weight correspondingly increase their general stiffness and resistance to blows, besides decreasing the wind-surface.

The particular structure shown for this design is a single-track span on the line of the Memphis and Birmingham Railroad, over the Big Warrior River, in Alabama. The centre depth of the truss is 49 feet 6 inches, and the depth at end 33 feet, both measurements being taken between chord-centres. The trusses are 13 feet apart centres, and are designed with effective systems of upper and lower lateral and transverse bracing. The vertical posts are designed for the full length between chord-centres, the influence of the rod running midway of the depth of the posts at and adjacent to the span-centre having been entirely neglected in the computations.

The stringers are riveted between the floor-beams, and the latter are riveted between the posts above the pins, thus securing the maximum of lateral stiffness.

The entire structure is of wrought-iron, with open compression-members, composed of plates and built channels latticed, as shown.

DESIGN "K."

In many cases it is desired to connect masonry piers across an opening where the clear space below is not limited. Under such circumstances, the types of trusses shown in this and the following design can be most economically employed. This truss is designed with short panels, and the following with long ones.

There are six panels of 13 feet 4 inches each, and the depth of truss is equal to the panel length. The trusses are placed 10 feet apart centres, so that the ties rest directly on the upper chord. The latter is so proportioned as to resist the consequent bending in combination with the direct compression. A judicious selection of panel length enables the proper balance to be maintained between chord-bending on the one hand and the advantage of a long panel on the other. Effective systems of upper and lower lateral and transverse bracing are easily secured in such a bridge, and give the requisite general stability.

This bridge carries the line of the Chesapeake and Ohio Railway over Dunlap's Creek.

DESIGN "L."

Extended experience has shown that a proper design of the upper chord of a deck-bridge, with long panels, obviates the necessity of a system of wrought-iron cross floor-beams and longitudinal stringers, and results in corresponding economy, by using heavy ties extending the full width of the bridge and resting directly on the upper chords. The design under consideration illustrates this type of structure, which can be satisfactorily used up to spans of such length that the width between truss-centres would forbid the use of the requisite timber ties. This length may be taken at about 225 feet.

The trusses shown in the design form one of five spans across the Potomac River, near Shepherdstown, Va., on the line of the Shenandoah Valley Railroad. Each span is divided into five panels of 25 feet, with two end-panels of 19 feet 6 inches. The trusses are placed 12 feet apart centres, and have a uniform depth of 27 feet between chord-centres over three intermediate panel lengths and 20 feet 4½ inches at the ends.

The decreased end-depth materially increases the lateral stability of the structure, both against the wind-pressure and the shock and vibration of moving trains.

The question of lateral stability without excessive anchorage to masonry becomes serious in long deck-spans, and is simply and effectually overcome by the decreased end-depth shown in this design.

The heavy bending moment produced by the moving load in the long panels is resisted by giving to the upper chords a depth of 30 inches, and properly stiffening the side-plates. Provision for the combined bending and direct chord-compression is thus amply and economically made, and all the benefits of long panels secured.

A heavy system of upper lateral bracing carries the wind-loads from the train and upper half of the truss to the tops of the inclined end-posts, from which points it is carried to the feet of those posts by proportionately heavy end transverse bracing. Intermediate transverse bracing between each pair of posts and the bottom lateral system complete the lateral and transverse bracing of the structure.

DESIGN "M."

The application of our system of construction to a long deck-span is well shown by this bridge, built for the Galveston, Harrisburg and San Antonio Railroad. The length of span, which is 300 feet, necessitates such a distance between the trusses that it is impracticable to place the ties directly on the upper chords. The usual transverse floor-beams are placed directly at and over the panel-points, and held rigidly in place by inverted loops.

Two lines of longitudinal stringers, 6 feet apart centres, carry the single line of rails, while two other lines over the two trusses make ample provision for the sidewalks.

The stringers are placed on the floor-beams, and braced firmly in position and stiffened by the heavy brackets, as shown.

The depth of the truss is 37 feet 8 inches, and length of panel 17 feet 8 inches. The advantages of a long panel, combined with an economical angle of ties, are thus secured by employing two systems of triangulation.

Complete transverse and lateral stability, both upper and lower, are effectually obtained in the usual manner.

Although there are eight lower chord eye-bars in the centre panel of each truss, they are so proportioned and arranged that the stress on the extreme pin-fibre does not exceed the proper limit.

DESIGN "N."

The distribution of material in a long span drawbridge, so as best to subserve the purposes of its construction, is a problem requiring the most careful consideration in all its details. It may be safely asserted, however, that the object of structural design has rarely, if ever, been accomplished in a more satisfactory manner than in this particular case.

The heavy bending over the centre pier is controlled by a comparatively small amount of metal, in consequence of the increased depth of the truss at that point; while the stresses in the web members in the vicinity of the centre are materially relieved by the greater chord inclination at the same place. The outer portions of the two arms, in which the stresses change in kind under the passage of the moving load, possess a depth of comparatively small and nearly uniform value. This meets in a most rational and effective manner the requirements of the relatively small stresses existing in these parts of the structure. The curved upper outline of the trusses thus combines the excellencies of an economic system with a remarkably graceful appearance.

As the bridge carries a double-track railway, with two trusses 26 feet apart between centres, it is readily seen to be a very heavy structure. The end and centre depths (20 and 40 feet, respectively) are so taken in connection with the panel length of 17 feet 5½ inches, however, that the greatest economy is attained.

The turn-table is wholly rim bearing, and the drum, 28 feet 2 inches in diameter, is carried on forty-two 24-inch rollers.

This type of structure is peculiarly adapted to the purpose of securing that degree of economy in construction and ease and stability in turning which are so essential in a long and heavy drawbridge.

A further description of this bridge will be found on another page.

DESIGN "O."

The most economical method of carrying a railway across a wide gorge in which firm pier foundations are easily secured at all points is illustrated in a remarkable manner by this structure. The total width of gorge is divided into twenty-one open spans and twenty tower spans, the former of about 60 feet, and the latter of about 40 feet. The greatest height is about 300 feet.

Each of the towers is thoroughly braced longitudinally and transversely in order to resist not only the wind-pressure, which acts with great severity on a structure of such extreme height, but also the thrust and vibrations caused by the moving loads.

The lateral pressure of the wind against a passing train at great elevations produces an overturning effect of unusual magnitude, which in this case has been amply provided for by the inclination of the columns and the anchorage at their feet.

The wind-pressure on the structure and its train-load was taken at 30 pounds per square foot, and 50 pounds per square foot for the unloaded structure. Subsequent tests

on large surfaces, at the site of the Forth Bridge, have demonstrated that these values give abundant security against wind-stresses.

The towers are divided into stories of about 33 feet each, at the extremities of which the column sections are joined by interior wrought-iron sleeves, forming a complete cylinder. By means of these cylindrical sleeves each column is made absolutely continuous from the top of the tower to the masonry at its base.

The lattice-girders forming the superstructures are of the deck variety and 10 feet apart centres, but possess no special characteristics other than being remarkably substantial structures.

DESIGN "P."

This design shows a highway bridge built by us for the Pottstown Bridge Company, of Pottstown, Pa., and the structure crosses the Schuylkill River at that place. There are two spans of 179 feet each from centre to centre of end-pins. The trusses are 21 feet 4 inches apart centres, with two sidewalks about 5 feet each in the clear. This bridge is typical of our usual highway construction.

It will be observed that the marked advantages of long panels and a single system of triangulation are secured by the use of a system of intermediate transverse iron beams, one resting at the centre of each panel on a pair of main longitudinal iron stringers. The latter are supported on the main floor-beams a short distance from the points of support of the latter, thus adding very little to their bending movements. 6-inch eye-beams and the two main stringers just mentioned form the joists which carry the floor-plank. Two lines of light timber joists, one outside of each main stringer, receive the spikes which hold the plank in place.

The sidewalk railing acts as a truss, with a span of one panel length, for half the sidewalk and its load. The sidewalk planks are spiked to the top of the guard-timber as shown; in this manner the footwalk is raised an agreeable distance above the roadway.

By this method of construction a permanent, light, and economical iron-floor system is obtained, the only inflammable portion being the necessary plank floor.

Efficient systems of upper and lower lateral and transverse bracing give in themselves complete stability against moving-load vibrations and the wind, though they are very materially reinforced by our system of floor construction.

DESIGNS "R" AND "S."

A combination of most unusual exigencies of extraordinary load and spans demanded special consideration in these designs and governed their characteristic features.

Two of the three river spans of the Cincinnati bridge, which this design represents, are 490 feet in length between centres of piers, while the centre-span is 550 feet between pier centres. They are two truss structures, carrying a double-track railway between the trusses, and a cantilever roadway and sidewalk, with a combined clear width of 16 feet on the outside of each truss. The entire floor is in the plane of the lower chord, and, as the trusses are 30 feet apart centres, its total width is about 66 feet. The total moving load thus becomes essentially equivalent to 7500 pounds per lineal foot of span, and the total dead load of the 550 feet span is about the same, making the total load carried equal to 15,000 pounds per lineal foot. The centre depth of trusses for the 490 feet span is 75 feet, and that for the 550 feet span is 84 feet. By a judicious use of the

system of intertrussed web, combined with a panel length of about 27 feet, the phenomenally large loads are carried in these high trusses on a single system of triangulation. In this manner the maximum of economy is attained, with all the advantages of perfectly determinate stresses.

This system of web design offers special advantages for bracing together adjacent pairs of posts in towers in the most efficient manner.

The requirements under which this structure has been built constitute a crucial test of the fitness of the design for spans of extraordinarily great length, carrying unusually heavy loads.

A system of stiff lateral bracing in the planes of the upper chords carries all the wind-loads to heavily-braced portals designed to resist the resultant bending and overturning stresses developed in the plane of the end-posts. Transverse bracing is placed in the plane of every pair of main and secondary posts, and it is designed to resist both the wind and eccentric loading of the railway tracks.

Each truss carries a solid board-screen 10 feet high, placed just above the roadway floor, in order to cut off all view of the railway traffic from passing trains. The wind-pressure on this screen and other lower parts of the structure necessitates a lower lateral system proportionately heavy with the trusses. The lateral connections, with floor-beams and posts, are so made as to make the centre-lines of stresses intersect truly under the

centres of the pins, thus obviating twisting, and other secondary stresses, and securing a very rigid connection.

The railway floor-beams and roadway cantilevers are secured to the posts above the pins by a connection subject to shearing only, while the lower flanges of both are riveted together, and secured to the bottom of the posts. This connection materially increases the lateral stiffness of these high trusses, and subjects the connecting-rivets to shear only.

All parts of these spans are of steel, except the lateral systems of bracing, and the floor-beams and stringers, which are of iron. The upper chords and end-posts are composed of three vertical 30-inch web-plates, and a 30-inch cover, built up with eight lines of angles, braced on the under side with 5-inch lattice-bars. The vertical posts of the trusses are composed of channels built of angles riveted to 20-inch plates and heavily latticed together. The intermediate inclined posts are similarly constructed with 16-inch plates.

The four lines of stringers for the double-track railway are held together in pairs, under each track, by stiff angle-bracing, and are so secured to the floor-beams as to be held firmly in place, and at the same time are prevented, absolutely, from taking any tensile stress resulting from the elastic stretch of the lower chord due to a moving load covering the entire span, thus affording a satisfactory and complete adjustment, which is very essential in spans of great length.



DESCRIPTION OF PLATES.

PLATE I.

MIDDLE BROOK BRIDGE.

THIS structure carries the four tracks of the New Jersey Central and Bound Brook Divisions of the Philadelphia and Reading Railroad across Middle Brook, near Bound Brook, N. J. The trusses are 28 feet apart between centres, and the span is 128 feet, divided into seven panels of $18\frac{1}{2}$ feet. The depth of 32 feet is so taken as to preserve the proper balance between economy of material in the bridge as a whole and judicious design and arrangement of the individual truss-members. The extraordinarily heavy load carried by the centre truss, as well as the somewhat unusual characteristics of the traffic, give to the design of this structure more than ordinary interest. The anthracite coal region finds one of its main outlets over the New Jersey Central Division, and thus puts upon the bridge a continuous and very heavy traffic, while the New York and Philadelphia express trains over the Bound Brook route move at a speed certainly not surpassed in this country. There is thus combined in the duty performed by the structure essentially the highest limits of requirements respecting rapidity of movement and weight of passing loads. The floor system, composed of twelve lines of longitudinal stringers rigidly secured between the transverse floor-beams, admirably fulfils the requirements of such exceptional conditions. The depth of trusses gives very stiff transverse bracing, and the construction of the floor system increases very materially the lateral stability.

The heavy loads carried by this bridge involve the use of the eight-segment Phoenix column and a number of heavy eye-bars of 12 square inches in sectional area.

PLATE II.

SUNBURY BRIDGE.

The single track of the Mahanoy and Susquehanna Division of the Philadelphia and Reading Railroad crosses the Susquehanna River at Sunbury, Pa., on the through structure shown in this plate. Ten spans of 192 feet each are on a tangent, while four of about 156 feet each are on an eight-degree curve, making a total length of about half a mile. All the trusses are 32 feet deep, but a separation of 16 feet between truss-centres for the spans on the tangent is changed to 21 feet for those on the curve. The 192 feet spans have each eleven panels of 17 feet $5\frac{1}{2}$ inches, while each of the other spans is composed of ten panels 15 feet 7 inches in length. The bridge was designed to meet the requirements of the heavy traffic of the Philadelphia and Reading Railroad, and its general

(28)

proportions are such as not only to fulfil those conditions, but also to form a most graceful structure, adding a very agreeable feature to its picturesque location. The pleasing effect is increased by the ornamental character of the Phoenix column.

The principal features of the construction are sufficiently well shown by the phototype to render unnecessary a detailed description. Perfect lateral and transverse stability is secured, and the floor system meets the highest requirements of the best practice. It is an excellent illustration of the most modern form of single-track through bridge.

PLATE III.

CHAUDIERE BRIDGE.

The Ottawa River is spanned at Ottawa, Ontario, by this bridge, which was built for the Quebec, Montreal, Ottawa and Occidental Railway, now forming a portion of the Canadian Pacific system. Although the plate shows but six spans, there are thirteen, seven of which are separated by an island from the six that are shown. In all the spans the trusses are 16 feet 6 inches apart centres, but the depth of 34 feet 6 inches of the 255-foot spans is reduced to 30 feet for the others. The panel length of 17 feet 1 inch is uniform for all the spans except the longest, in which it changes to 17 feet 3 inches.

It is a "through" structure, carrying a single track, and is nearly 2100 feet in length. The method of securing the floor-beams to the posts, by riveting just over the lower pins, is the only peculiar characteristic of the construction, and was required by the Railway Company. This feature, in connection with the placing of the stringers between the floor-beams, gives rise to a very stiff floor system, and materially increases the lateral stability.

The track rests on ties carried by a system of four longitudinal stringers, constituting a floor of sufficient continuity and strength to provide for any ordinary derailment. These stringers are 4 feet apart between centres; the two adjacent to the centre of the track are, therefore, heavier than the others.

The track is about 25 feet above the water at ordinary stage.

PLATE IV.

BIG WARRIOR BRIDGE.

Some details regarding the 300-foot span of this bridge have been given in the matter descriptive of Design "K." It is located near Cordova, Alabama, at the point where the Memphis and Birmingham Railroad crosses the Big Warrior River. The railroad con-

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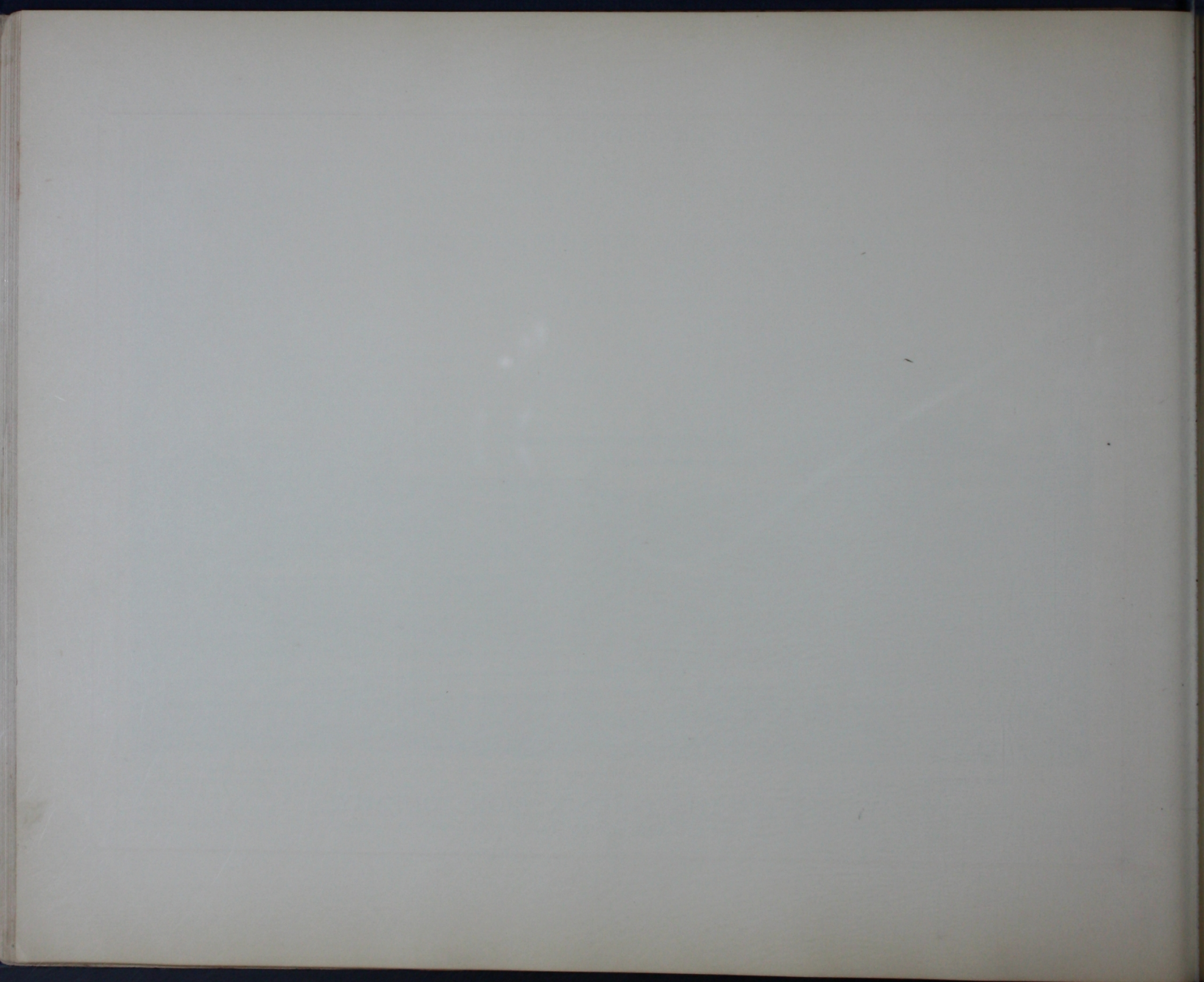


Blast Furnaces.

Rolling Mills.

Puddle Mills.

WORKS OF THE PHŒNIX IRON COMPANY,
PHŒNIXVILLE, PA.



nects the cities of Memphis and Birmingham, and affords an outlet to the Northwest for the heavy coal and iron traffic of the latter city, as well as the supply for its many furnaces and mills from the extensive coal and iron fields traversed by the railroad. The traffic is therefore necessarily heavy and very frequent, and the bridge structures are required to be of corresponding strength and stiffness. Both the 300 feet and 150 feet spans which compose the iron portion of this structure are designed with a view to these requirements. Floor-beams are riveted between posts, and stringers between floor-beams; these features, together with heavy lower lateral, transverse, and upper lateral systems, afford a structure well adapted to perfectly resist the wear of the heaviest traffic for any length of time.

The 300 feet span was subjected to a very severe test immediately after the removal of the false-work and before the rivets in the upper chord-joints were driven. While these joints were temporarily bolted, it became imperatively necessary for the Railroad Company to pass trains over the bridge. Under these trying circumstances, the bridge carried its traffic with perfect stiffness and in the most satisfactory manner.

PLATE V.

CATSKILL BRIDGE.

Of the many picturesque locations along the line of the New York, West Shore and Buffalo Railroad, there is, probably, none in which the art of the engineer combines more harmoniously with the quiet beauty of the natural scenery than at the site of this structure. The village of Catskill, prettily located on the bank of the Catskill Creek, and at a considerable elevation above it, in one of the most charming portions of the valley of the Hudson, looks down upon this bridge as it carries the railway line over the creek and adjacent valley.

As the plate shows, the bridge is a double-track deck structure in eight spans,—six of 170 feet, and one each of 100 and 106 feet, with a total length of 1250 feet. The depth of the long spans is 26 feet, and panel length 16 feet 8 inches, while the depth and panel length of the short spans are 21 and 17½ feet, respectively. The trusses are 20 feet apart centres in all the spans, and the track is 85 feet above the water. Like all constructions for the New York, West Shore and Buffalo Railway, it was required to meet in all respects specifications based on the demands of the most advanced bridge practice of the present day. By the use of an independent floor system, with transverse floor-beams resting at the upper chord-panel points, a length of panel could be selected which would be productive of economy in trusses, and leave all stresses well defined.

As the two trusses are 20 feet apart centres, with depths of 21 and 26 feet, excellent proportions for effective transverse bracing are secured. The economy of oblique end-posts is attained by using vertical columns at the feet of the end-posts, which carry a panel-moving load.

This bridge meets the requirements of a heavy and rapidly moving traffic, with a high degree of constructive economy.

PLATE VI.

THE GENESEE RIVER BRIDGE.

This structure, built in the summer of 1887, stretches across the gorge of the Genesee River, in the City of Rochester, New York, where it is crossed by the Rome, Watertown

and Ogdensburgh Railroad, for which Company the structure was built. The grade of the railroad is about 114 feet above the bed of the river and about 102 feet above the bottom of the gorge between its east bank and the river, this strip of land being submerged only at high water. Probably few engineering works in this country embrace the same variety of structures. Plate and lattice-girders, pin-spans with and without floor systems, viaduct towers and bents, all are combined to produce the complete structure, which is of the deck type throughout.

Beginning at the west end there are three 40 feet deck plate-girders on a 10½ degree curve, followed by one 200 feet deck pin span on tangent with plate-girder floor-beams and stringers, after which is found one 100 feet deck pin span with ties directly on the upper chord; thence to the east end three 30 feet deck plate-girders alternate with three 65 feet deck lattice-girders, making a total length of 705.0 feet. The entire structure is of wrought iron, and the various portions are so designed in reference to each other as to result in a most rigid whole.

Every feature is the expression of a constructive purpose and in accordance with the best engineering design, which results not only in economy but also in the attainment of a most substantial and rigid bridge structure. Rocking posts and sliding surfaces afford effective facilities for motions resulting from changes of temperature, while lateral and transverse systems of bracing secure absolute stiffness against the shock of trains and the pressure of the high winds frequently prevalent at this locality.

The structure is most admirably adapted to the high-speed traffic required by the Railroad Company over this part of their line.

PLATE VII.

HARLEM RIVER BRIDGE.

The graceful outline of this drawbridge indicates that the demands of the location involved not only considerations of structural economy, but those of an æsthetical character as well. It is a double-track structure, crossing the Harlem River at Eighth Avenue, New York City, and connects the West Side and Yonkers Railway with the Eighth Avenue Elevated Road.

With a centre depth of 40 feet, and 20 feet at the end, the intermediate depths are so taken as to secure both beauty of outline and a proper regard for economic considerations. In fact, the varying inclination of the upper chord not only produces an agreeable impression on the eye, but is in reality a true expression of a correct distribution of material. No structure could be more admirably adapted to the complex requirements of the location. There are sixteen panels of 17 feet 5½ inches, and one of 18 feet 5 inches.

The trusses are 26 feet apart centres, and carried at the pivot pier by a wholly rim-bearing turn-table fitted with the proper appliances for steam as the motive power. The diameter of the drum is 28 feet 2 inches, and turns on forty-two 24-inch rollers. Although a single system only of triangulation is used, by proper trussing the entire weight of the bridge and its load is equally divided between eight points of support on the drum, equidistant from each other.

The locking-gear and turning-machinery, with engine and boiler, are of the most approved character. They are located in the turn-table, and operate with great expedition and efficiency.

PLATE VIII.

ALBANY AND GREENBUSH BRIDGE.

The Albany and Greenbush bridge shown on this plate is the second one built by this Company across the Hudson River at Albany; it connects the village of Greenbush with the city of Albany at a point just south of the freight station of the A. and S. Division of the Delaware and Hudson Canal Company.

The necessities of this particular case are a combination of those usually found in separate structures; the difficulties presented, therefore, were of a correspondingly complicated character. A roadway with sidewalk on either side is carried along the lower chord, while a double-track railway is placed 19 feet above the lower chord-pins. The structure is, therefore, obliged to do double duty, and, with the length of spans required, it becomes unusually heavy.

The trusses are 28 feet apart centres, and the entire structure is composed of four "through" fixed spans of 150 and 250 feet in length, combined with a "through" draw-span 400 feet long, and three plate-girders at each end of 36-foot span, making the total length 1430 feet. The depth of the 250-foot spans is 45 feet, and that of the 150-foot spans 22 feet. The panel length is 16 feet 7 inches for the fixed spans, and 18 feet 3 inches for the draw, except at the drum, where there are two panels of 16 feet each.

The problem of placing a double-track railway platform midway of the depth of the long-span trusses and draw presented some interesting points of design not usually encountered in bridge-construction. All vertical compression-members in the bridge are of the ordinary latticed channel species above the railway platform, but below the latter eye-beams take the place of the latticing, and furnish points of support at their upper extremities for the railway floor-beams. The end-posts of the 250-foot spans are eight-segment Phoenix columns of the heaviest section ever rolled; they possess a cross-sectional area of 104 square inches.

The draw-span has a depth of 25 feet at the ends and 50 feet at the centre. The resulting inclination of the chords produces considerable relief of stress in the web-members. The four main posts at the pivot pier, with the double cancellation, made it necessary to consider each main truss as composed of two separate trusses, each continuous in itself, with one system of triangulation and two points of support at the centre.

The weight of the trusses and superincumbent load is distributed at ten points on the drum of the combined centre and rim-bearing turn-table.

This drum has a diameter of 34 feet, and depth of 42 inches.

The entire mass of drawbridge and turn-table weighs about 1000 tons, and is turned by steam in less than two minutes.

PLATES IX AND X.

KINZUA VIADUCT.

The structure from which the views in these two plates were taken has attained celebrity from its great height, and stands as one of the most remarkable examples of modern construction. It carries the single track of the New York, Lake Erie and Western Coal and Railroad Company across the Kinzua Valley, in Bradford County, Pa. The superstructure is composed of latticed deck-trusses, 10 feet apart centres, and alternately of 61- and 38½-foot spans. The towers vary in height from 20 to 280 feet. To this

latter height is to be added the depth of the latticed trusses and height of masonry, making a total elevation of 301 feet above the surface of the water in Kinzua Creek.

The towers are each composed of Phoenix columns for the main compression-members and transverse struts, with longitudinal struts of four latticed angles and diagonal tension-rods arranged in pairs as shown. Both longitudinal and transverse bracing were designed in view of the extraordinary circumstances of the location. Very high winds sweep through the gorge and produce conditions requiring the most careful consideration in connection with such an elevated structure, while its vibrations, caused by moving trains, call for scarcely less attention.

A train of consolidation engines formed the moving load under which the viaduct was designed.

The following is a recapitulation of the main data:

Number of iron towers	20
Number of columns	110
Number of spans	41
Total length of iron-work	2053 feet.
Length of each clear span	61 "
Length of each tower span	38½ "
Highest tower	297 "
Average height of towers	170 "
Width of top	10 "
Width of base (widest part)	103 "
Pounds of iron in viaduct	3,500,000
Pounds of steel in track and fastenings	100,000

Besides the railway track, the viaduct is provided with a sidewalk on each side.

PLATE XI.

RONDOUT BRIDGE.

One mile south of Kingston, N. Y., on the line of the New York, West Shore and Buffalo Railroad, the railway pierces the rocky ridge just north of Rondout, then emerging from the tunnel it is carried over the creek by the viaduct and through spans shown on this plate. The viaduct is adjacent to the tunnel, and the southern portion of it consists of eleven lattice deck-girders, alternately of 51- and 30-foot spans, with one exception of 20 feet and another of 60.

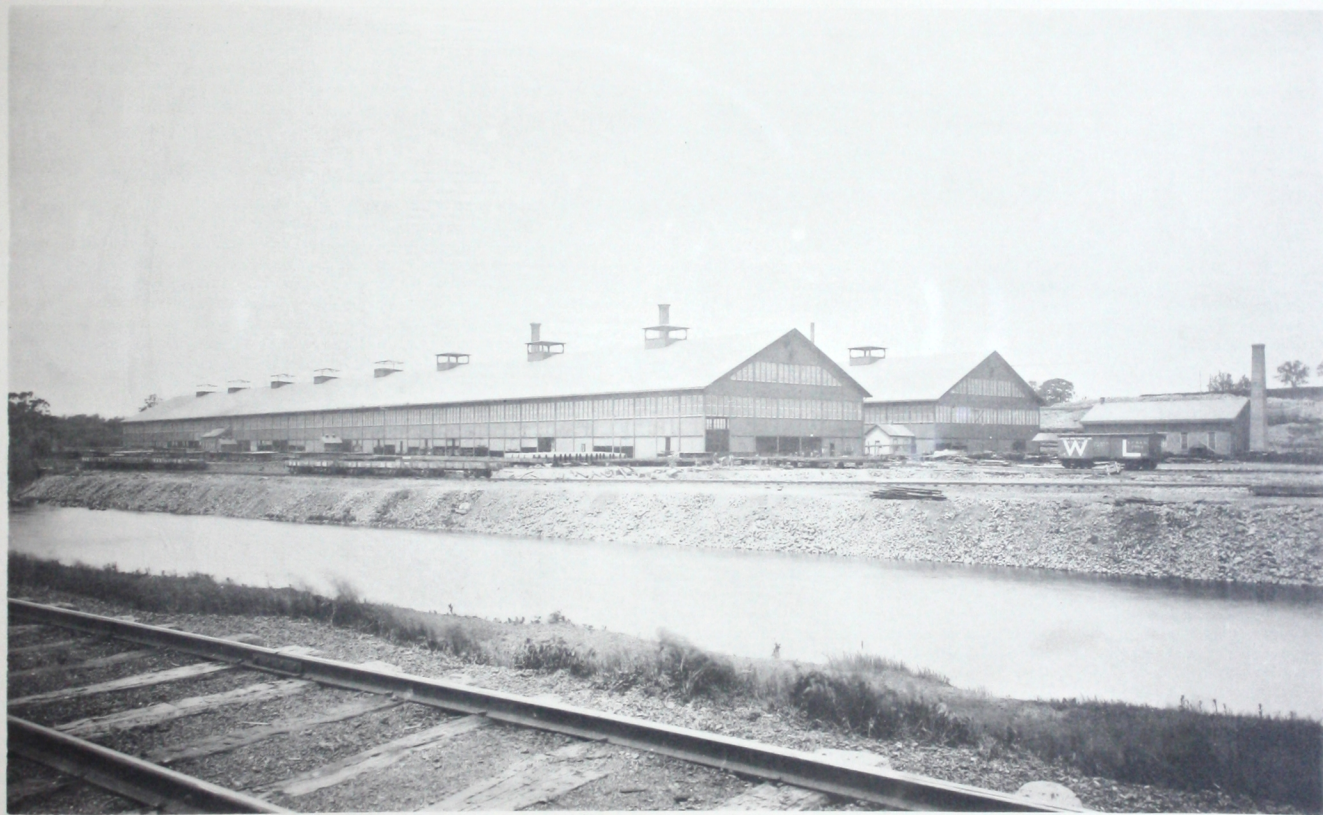
The northern portion consists of a series of three pin-connected spans, and the entire superstructure is carried on the top of towers varying from 32 to 140 feet in height. As shown on the plate, the two longer spans are over Rondout Creek, and at an elevation of 155 feet from base of rail to surface of water.

The separation of trusses in each through span is 29 feet, and the depth of the two longer spans 45 feet; the length of panel is 18 feet.

The general design of the structure is such as to secure the greatest economy of material, in combination with the requisite stability at such an elevation. As there are two trusses only to each pin-connected span, and a double track to be carried, the conditions to be fulfilled were such as are not ordinarily found.

The construction of the towers is admirably adapted to the requirements of stability

THE PHŒNIX BRIDGE COMPANY.

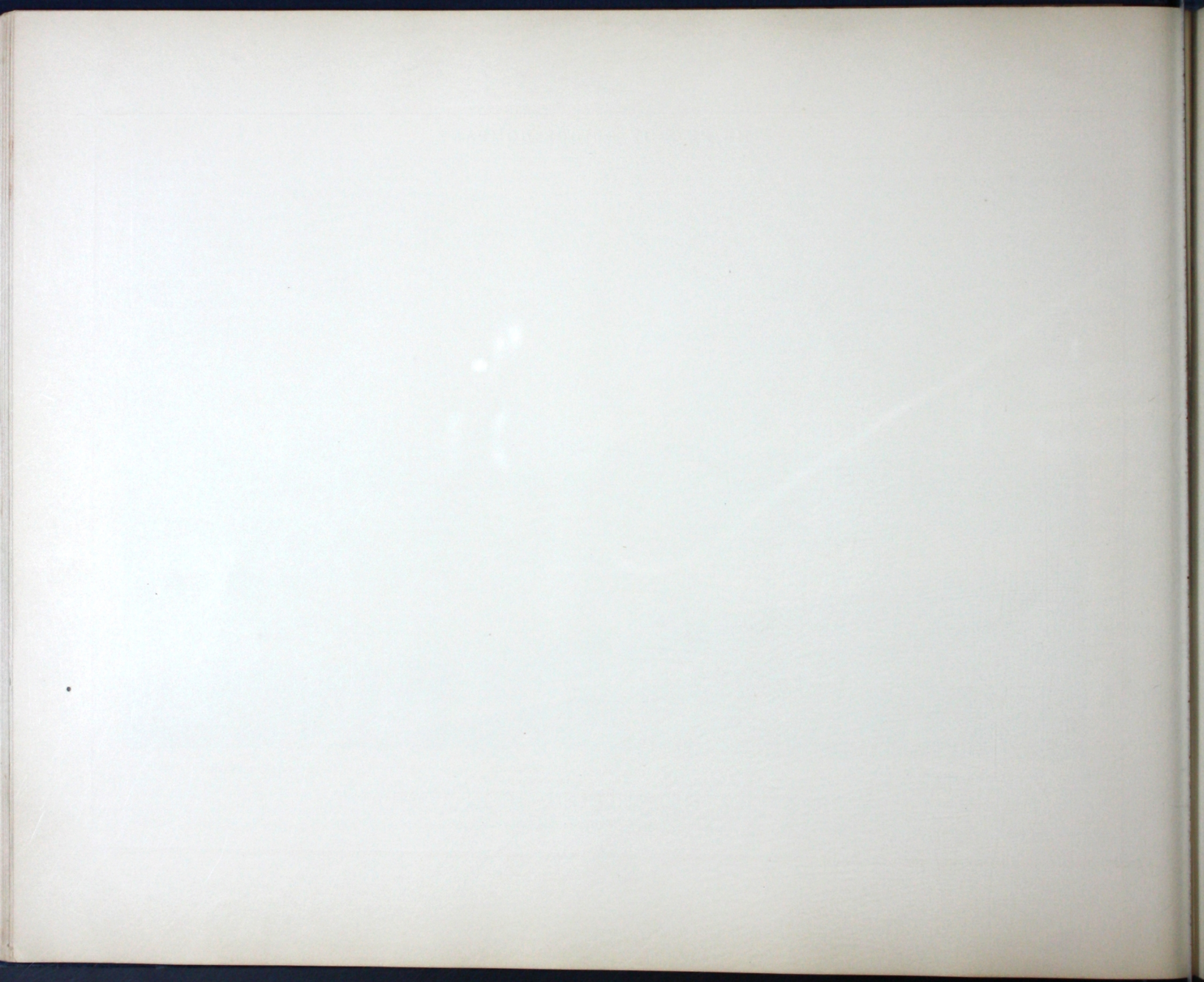


Length, 930 Feet.

New Rolling Mills.

Front, 430 Feet.

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PHŒNIXVILLE, PA.



and economy. Phoenix columns are used in compression, and all details are so formed as to act in the most direct and effective manner. The three through spans are so placed on the towers that their weights are equally distributed on the four legs.

The viaduct is 531 feet long, while the whole structure has a length of 1244 feet. The total weight of iron is about 2000 tons.

PLATE XII.

METROPOLITAN ELEVATED RAILWAY.

This plate shows some features in the construction of the Metropolitan Elevated Railway of New York City. The requirements of this work were certainly most unique, and at its inception the difficulties of design were unusual in engineering experience. The construction of an entire railway line on an elevated iron structure, to be subject to the demands of steam traffic, would give rise to more than ordinary engineering problems, but when these conditions are coupled with others, required by an almost absolutely continuous use of the structure, the difficulties encountered are very materially increased. Although the speed of the trains on the elevated railways of New York are not high, yet the short intervals of time between them permit scarcely any rest to the metal of the viaduct. Hence the fatigue of the iron becomes an important consideration.

This incessant use also gives rise to very wearing demands on the connections of the lateral and transverse systems of bracing, especially on the curved portions of the line, some of which are reversed.

This plate shows a portion of the road where the design was such as to meet the difficulties arising from a combination of greatly-increased height with a reversed curve. The inherent stiffness of the Phoenix column in all directions, as well as its superior capacity for resisting compression, render it peculiarly adapted to such extraordinary conditions as these. The transverse and lateral bracing, as well as the longitudinal bracing of the towers, were made sufficiently heavy to permanently meet the requirements of the circumstances. The whole amount of elevated railway built by this Company in New York City up to the present time is 39.3 miles of single track.

PLATE XIII.

KINGS COUNTY ELEVATED RAILWAY.

This line of elevated railway in Brooklyn, N. Y., completed during the early part of 1888, exemplifies the most advanced type of elevated structural work. It consists of double and three-track work, extending from Fulton Ferry along Fulton Street to a point beyond Sackman Street, making a total length of a little less than six miles, equivalent to an amount of single-track structure of between twelve and thirteen miles in length.

The charter of this Company required a lattice-girder structure with a line of columns on each side of the street, thus necessitating transverse girders spanning the distance between the curbs, on which are placed the longitudinal girders carrying the ties. On account of the frequent curves and almost invariably oblique intersection of streets along the line of Fulton, the lengths of both longitudinal and transverse girders in several instances considerably exceed 70 feet. These varied and numerous skew intersections

and curves, together with equally numerous grades, amounting between Sands Street and Fulton Ferry, where the heaviest traffic occurs, to $3\frac{1}{2}$ per cent., created constructive requirements more severe than any hitherto encountered in elevated-railroad designs; in fact, the demands were quite unprecedented. The rigidity of every part of the structure, and especially those portions on the sharpest curves and heaviest grades, under rapid and continuous traffic, demonstrates the excellence and efficiency of the design in every feature. The completeness of the lateral and transverse systems of bracing, and the ample provision for resisting the longitudinal thrust or pull of locomotive-traction and effect of brakes on the heavy grades, render this the most substantial and durable of all the latest lines of elevated structures.

The view shown represents a portion of the structure near Nostrand Avenue, with that station in the distance, as it appeared during construction. The lattice-girders, with inclined end-posts for the transverse, produce a light and graceful appearance in the structure and offer a minimum obstruction to light and air in the street.

The erection of the iron-work on Fulton Street near the Ferry was done wholly by a traveller carried on the track-girders already in place, and presented an engineering problem of much difficulty; but the entire structure was erected without the slightest accident.

PLATE XIV.

GIRARD AVENUE BRIDGE.

The Girard Avenue Bridge is one of the most celebrated roadway structures of its kind. It spans the Schuylkill River, in the city of Philadelphia, on the line of the main avenue of approach to Fairmount Park, and it is remarkable as the first attempt in this country to combine the American system of pin-connection bridges with a solid roadway of stone constructed in the most massive and substantial manner.

There are seven lines of trusses placed 16 feet apart centres, and united by horizontal and vertical bracing. All compression-members are Phoenix columns. Upon the top of the posts, and transversely, are laid heavy 15-inch eye-beams, and on these are placed longitudinally 9-inch beams 2 feet 8 inches apart centres. Transverse corrugated plates rest on the latter and support four to five inches of asphalt concrete, making a water-tight surface. The roadway is 100 feet wide and was originally paved with granite blocks in the usual manner, except that it is divided into seven ways by two lines of iron tracks, adjacent to the sidewalks, for horse-cars, and five lines of carriage tramways made of cut granite blocks 1 foot wide and laid to a 5-feet gauge. The total width of 100 feet is divided into one carriage-way of $67\frac{1}{2}$ feet and two 16½-foot sidewalks.

The moving load of 100 pounds per square foot, in addition to the weight of the structure, constitutes a total load of 30,000 pounds per lineal foot of bridge.

PLATE XV.

TRENTON CITY BRIDGE.

This roadway bridge was built for the Trenton City Bridge Company, of Trenton, N. J., and crosses the Delaware River at that place. There are seven spans with a total length of 1280 feet. Each span contains nine panels of 20 feet each, and the depth of truss is 26 feet. There is a clear width of 20 feet for the roadway, and 6 feet for each of the two sidewalks.

The design of this structure represents the most advanced system of construction as applied to the ordinary roadway bridge. Two lines of iron stringers extend the entire length of the seven spans, and carry at the centre of each panel an intermediate transverse beam, on which rest iron joists of half a panel length. All the economic and other advantages of long panels were thus made available, besides eliminating everything combustible, with the unavoidable exception of the floor-plank and three lines of light-timber stringers to which they are spiked.

The sidewalk railing serves the double purpose of a guard and trussed stringer for a portion of the sidewalk load. With its lines plainly expressive of the purpose of its construction, it materially contributes to the light and graceful, yet most substantial, appearance of the entire structure.

PLATE XVI.
CAPE MAY PIER.

During the past few years the field of engineering construction has been extended so as to cover ocean piers built entirely of wrought-iron, with the excepting of the timber floor, and that at Cape May is one of the finest examples to be found on the Atlantic coast. With its length of 1000 feet, and pavilion located at the outer extremity on an extent of 26,000 square feet of floor, there is ample space not only for the demands of business, but for the gratification of the crowds of people who delight to make the pier a promenade. Its adaptability to the latter purpose makes it one of the principal attractions of this popular summer resort.

The width of the stem of the pier is 30 feet, and the size of the head 130 by 200 feet, while the centre bay is 60 by 80 feet. The entire floor is elevated 21 feet above low water.

The columns are all of the Phoenix section and fitted at the lower extremity with cast-iron feet 24 inches in diameter. These were sunk 10 feet into the sand, and so rigidly braced together, both longitudinally and transversely, that the pier would stand firmly in position with no support but its own bracing.

The columns were sunk to the required depth by the water-jet process.

FRONTISPIECE.

SCHUYLKILL RIVER BRIDGE.

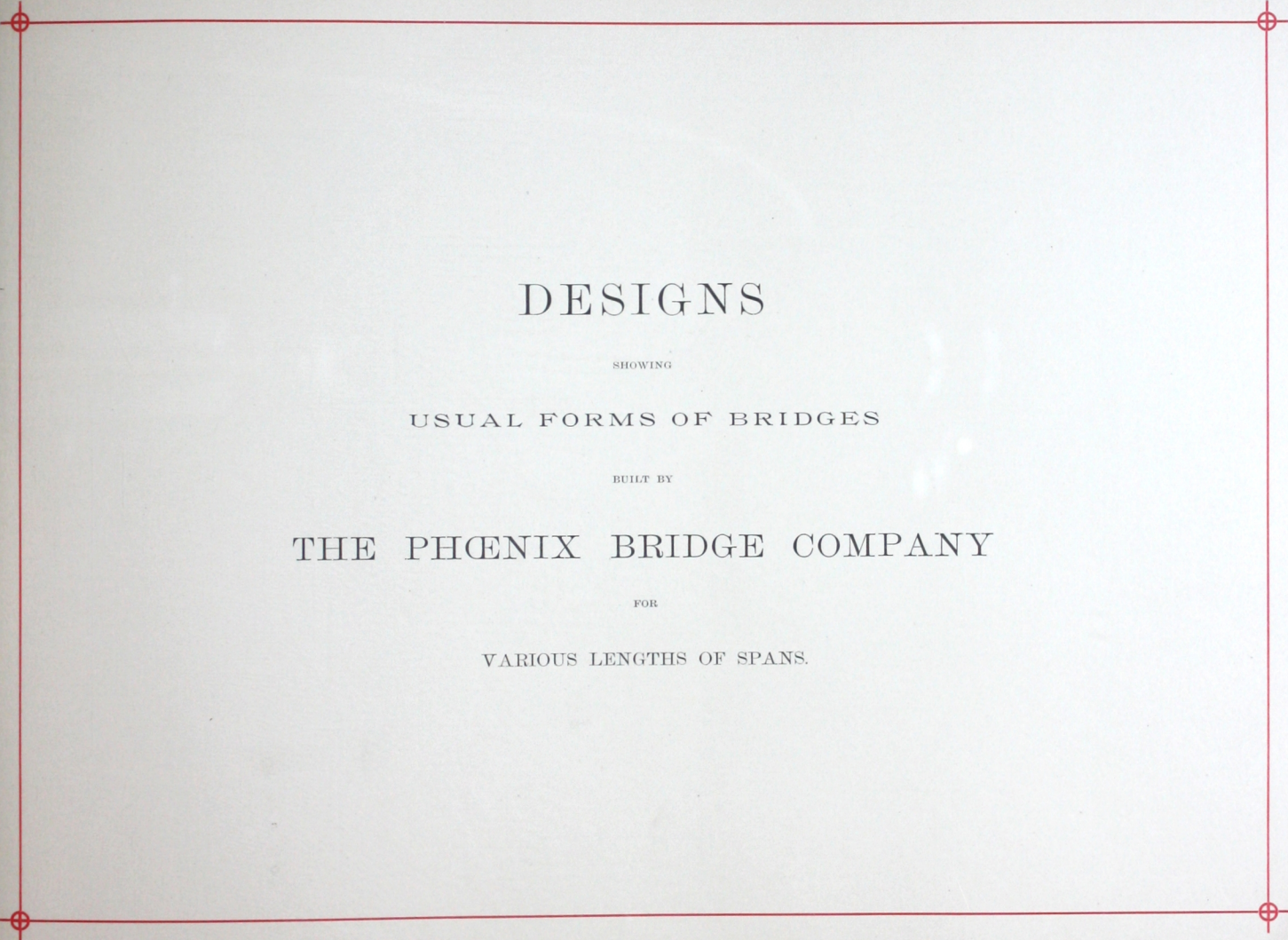
ON THE LINE OF THE PHILADELPHIA AND READING RAILROAD, AT PHILADELPHIA, PA.

This double-track railway-bridge, with one outside sidewalk, six feet wide in the clear, is known as the Columbia Bridge, and is located near Belmont Station, within the limits of the city of Philadelphia. It consists of one 128-feet 6-inch span at each end and five 142-feet 11-inch spans between the preceding, making seven double-track spans, with a total length of structure of 1031 feet. The six-feet clear sidewalk was made a part of the bridge for the purpose of accommodating the foot traffic developed by the old combined railway and highway wooden structure which preceded the present iron bridge built in the year 1886.

The trusses are 28 feet apart centres transversely, and 28 feet 9 inches deep from centre of upper chord to centre of lower chord. Two lines of plate-girder stringers placed 7 feet apart centres carry each track, and are riveted between the transverse floor-beams 5 feet deep. The design of the floor system thus involves every feature conducive to stiffness and strength under any traffic, whether freight, coal, or passenger, that the bridge can ever be called upon to carry.

The railway moving load, under which all the iron-work was designed, consists of two coupled locomotives, each weighing, with its tender, 184,000 pounds, and followed by a train-load of 3000 pounds per lineal foot for each track. The sections required under this moving load by The Phoenix Bridge Company's standard specifications, together with the lateral and transverse systems of bracing designed in accordance with the same standard, give to the entire structure characteristics of solidity and strength not usually found even in heavy railroad bridges. Its pleasing general effect adds materially to the beauties of the Schuylkill and its surroundings at this particular point.





DESIGNS

SHOWING

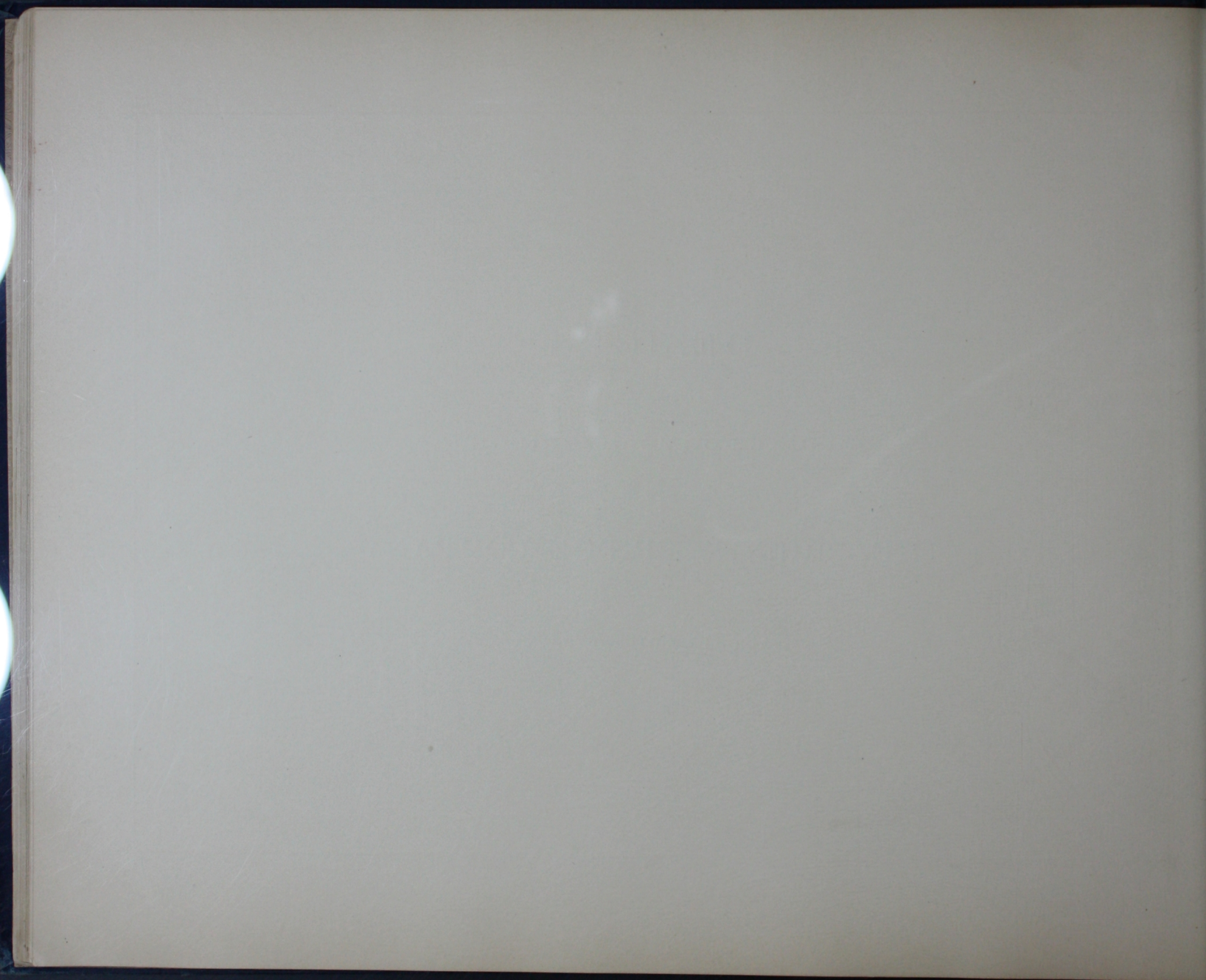
USUAL FORMS OF BRIDGES

BUILT BY

THE PHOENIX BRIDGE COMPANY

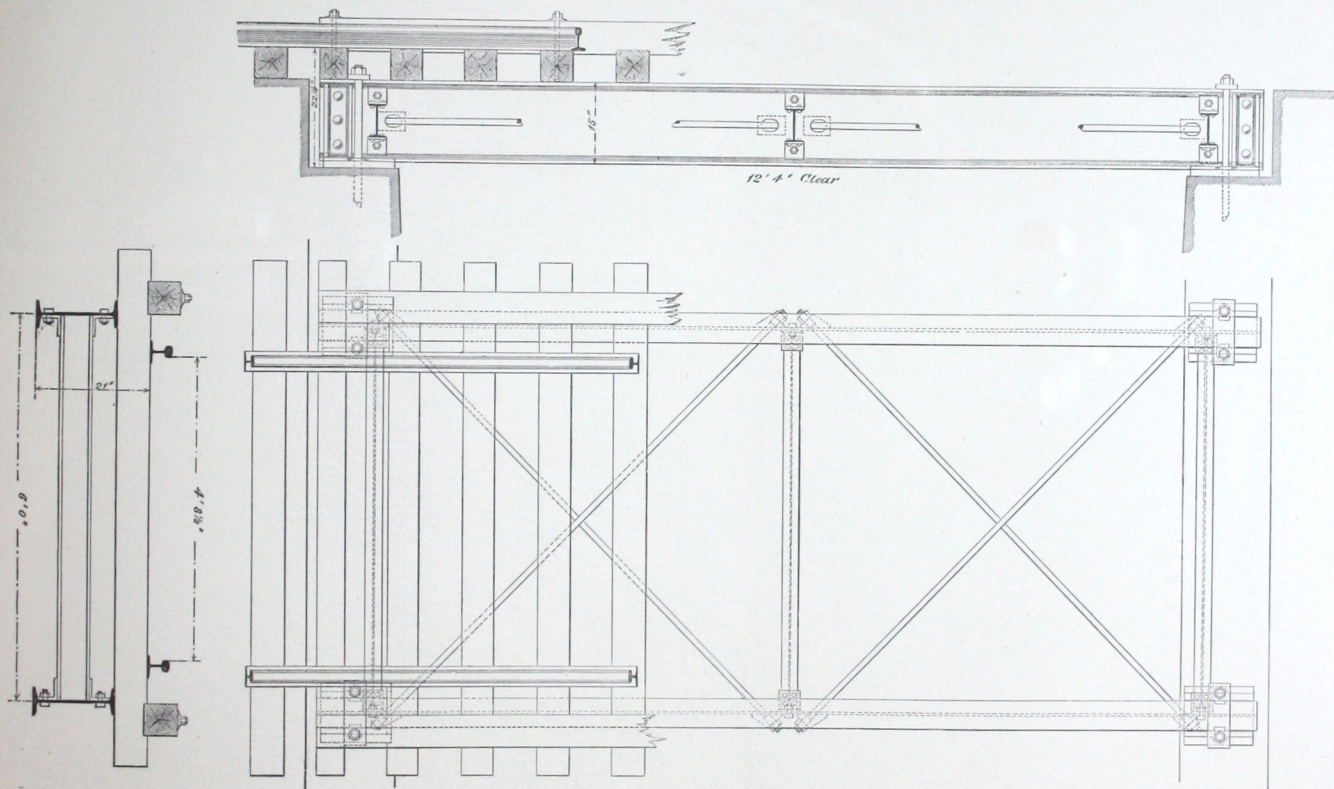
FOR

VARIOUS LENGTHS OF SPANS.



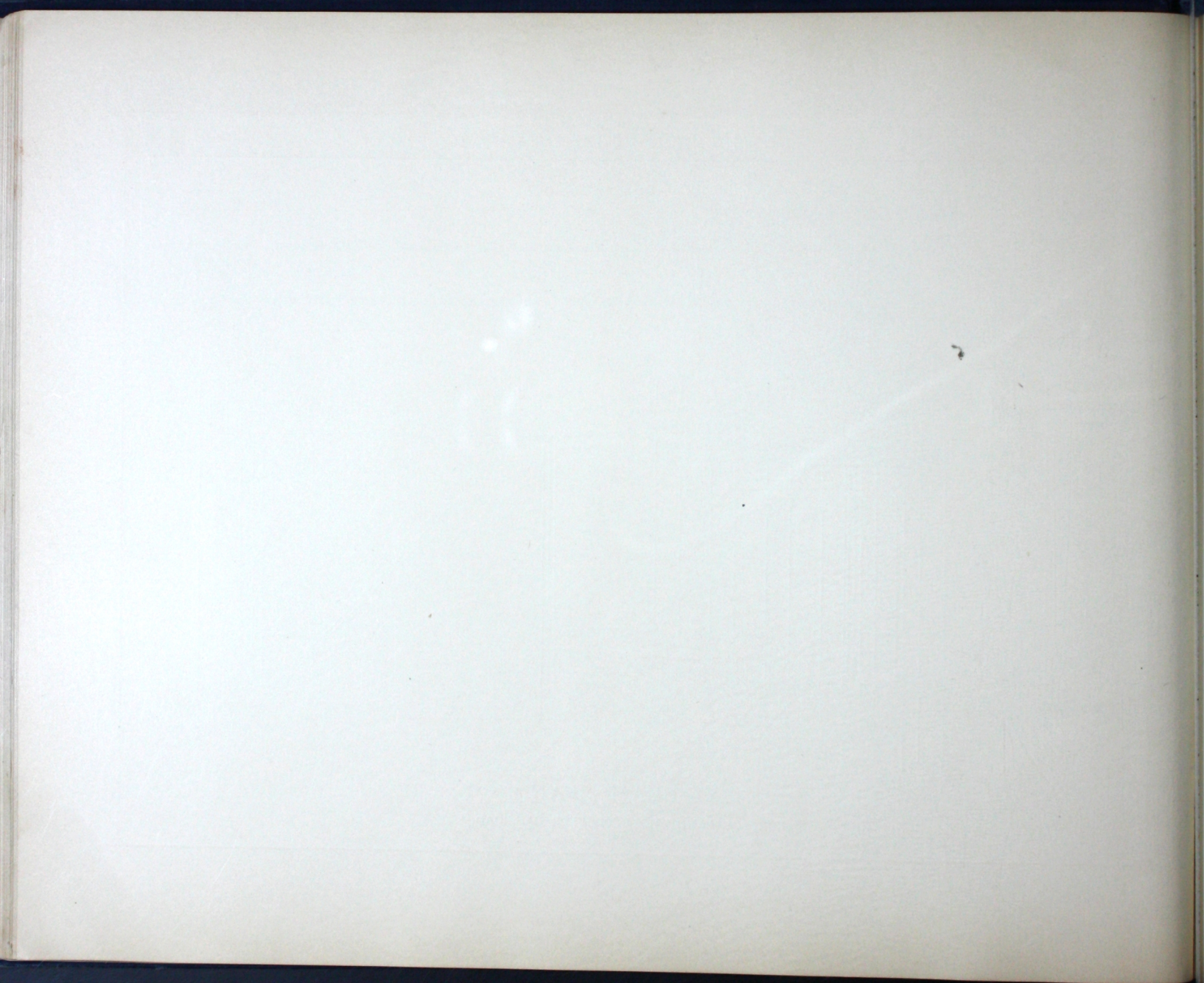
THE PHOENIX BRIDGE COMPANY.

DESIGN A.



EYE-BEAM SPAN,

FOR PORTLAND AND ROCHESTER RAILROAD.



THE PHOENIX BRIDGE COMPANY.

DESIGN B.

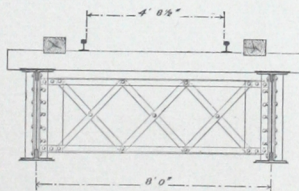
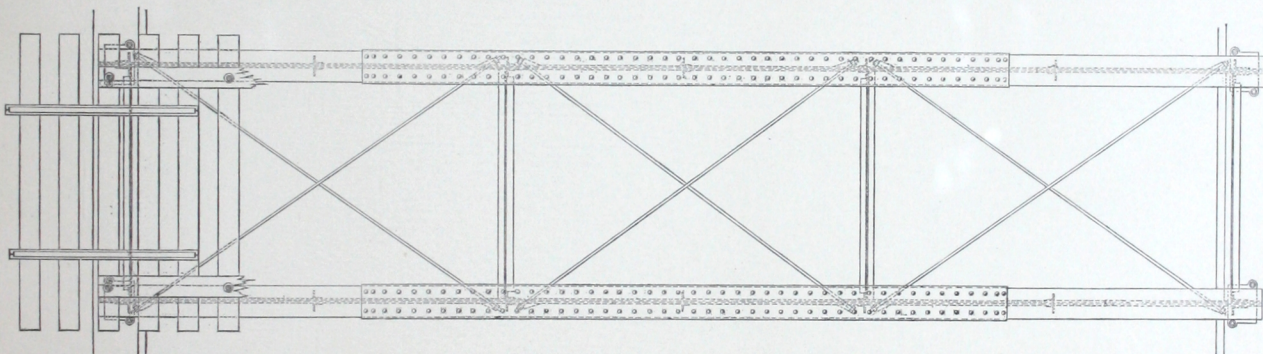
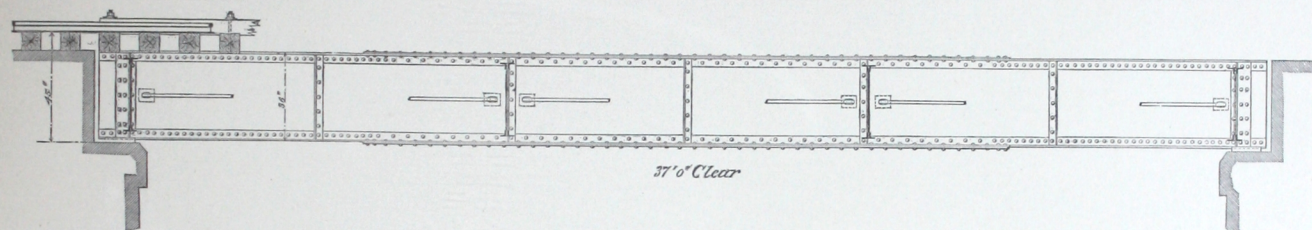
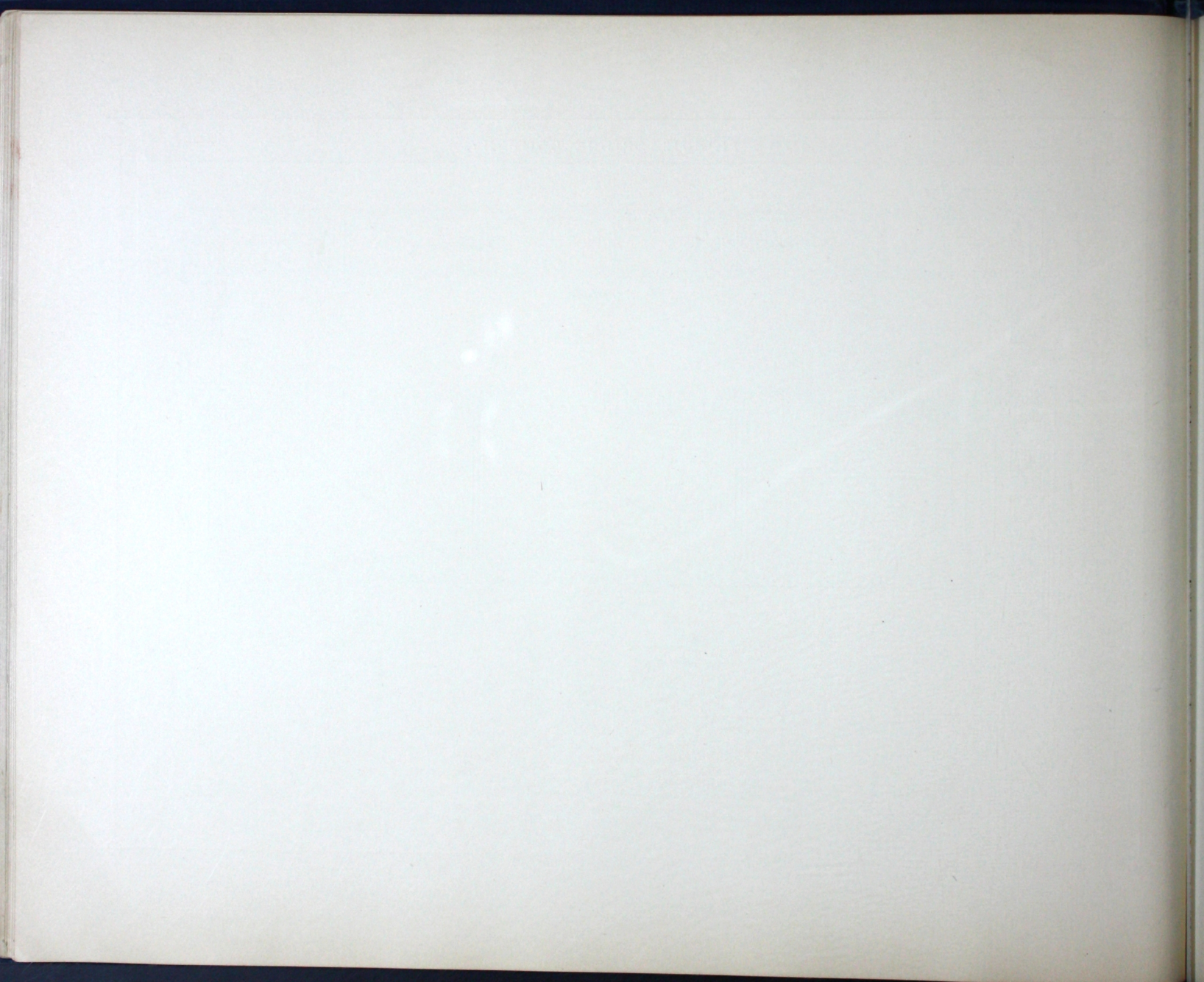


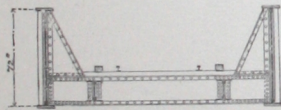
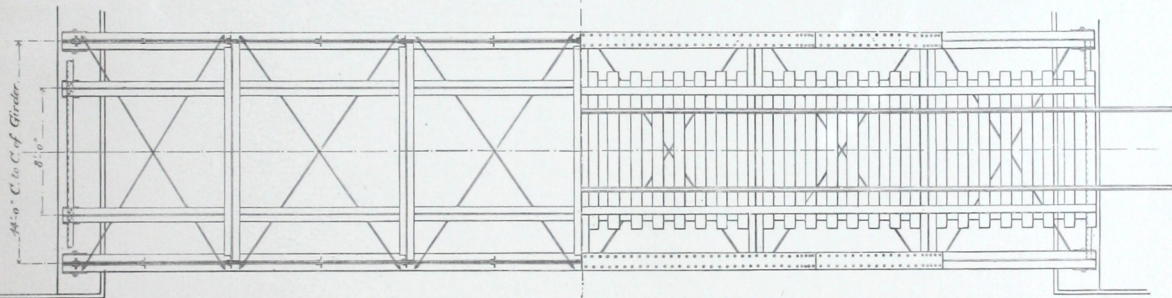
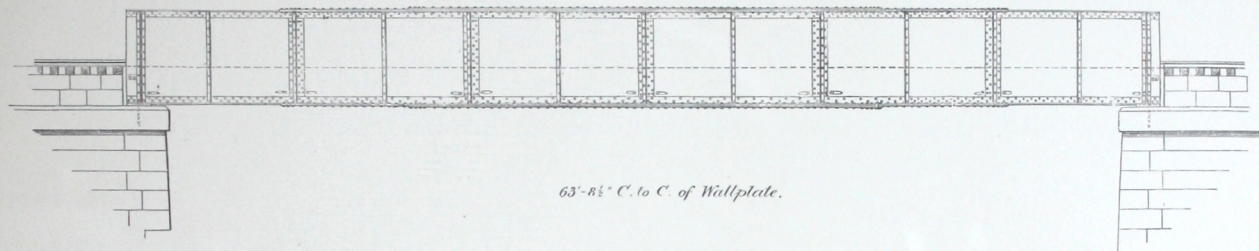
PLATE-GIRDER SPAN,

FROM MEHERRIN BRIDGE, SEABOARD AND ROANOKE RAILROAD.



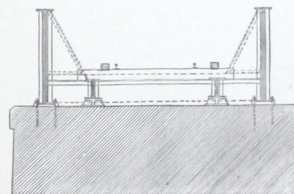
THE PHOENIX BRIDGE COMPANY.

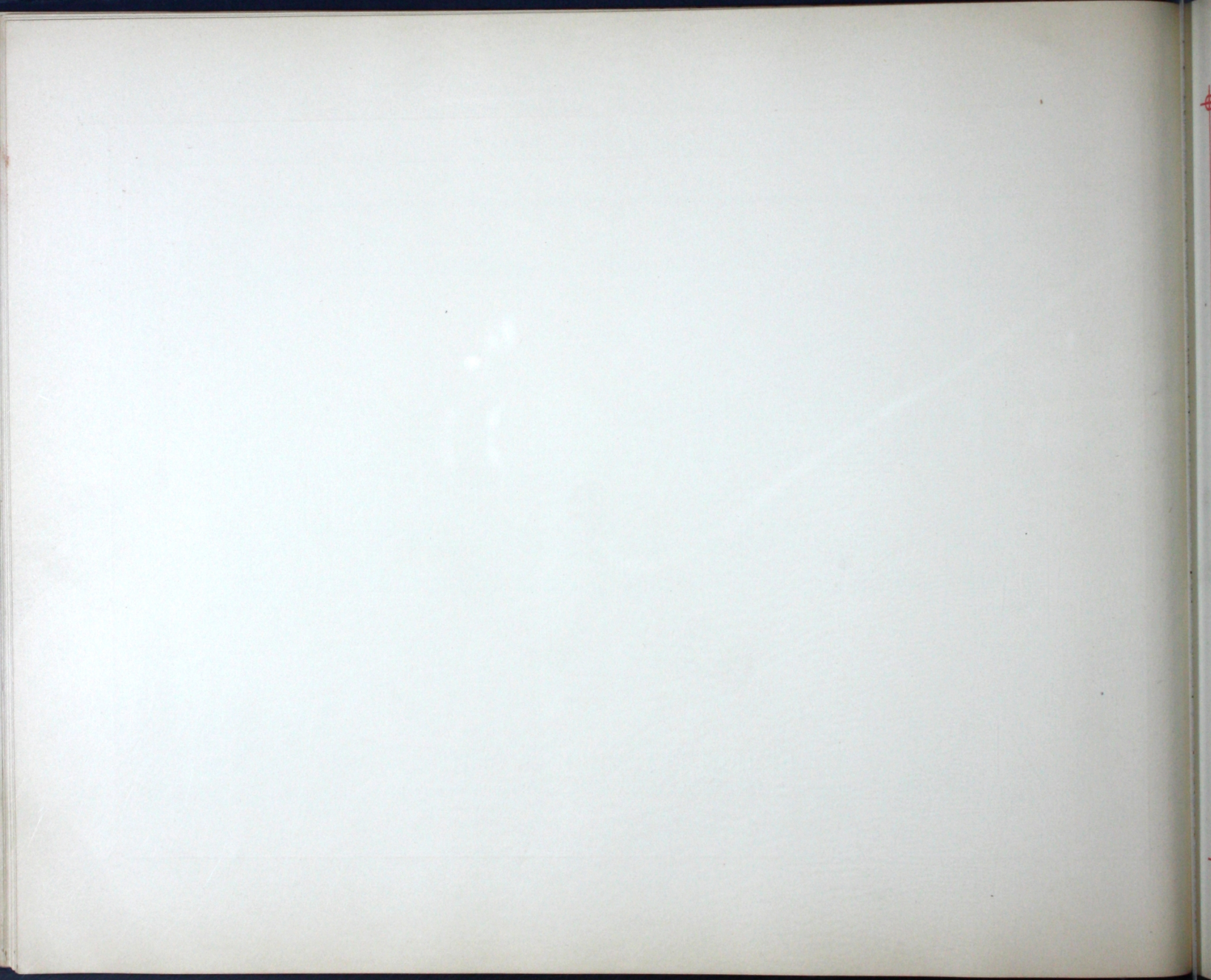
DESIGN C.



THROUGH PLATE-GIRDER SPAN.

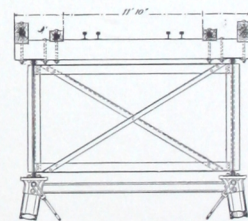
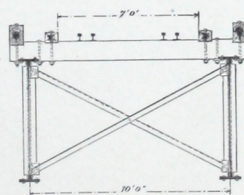
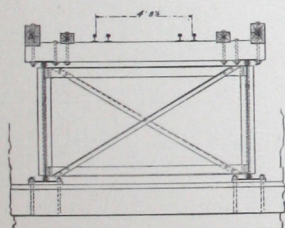
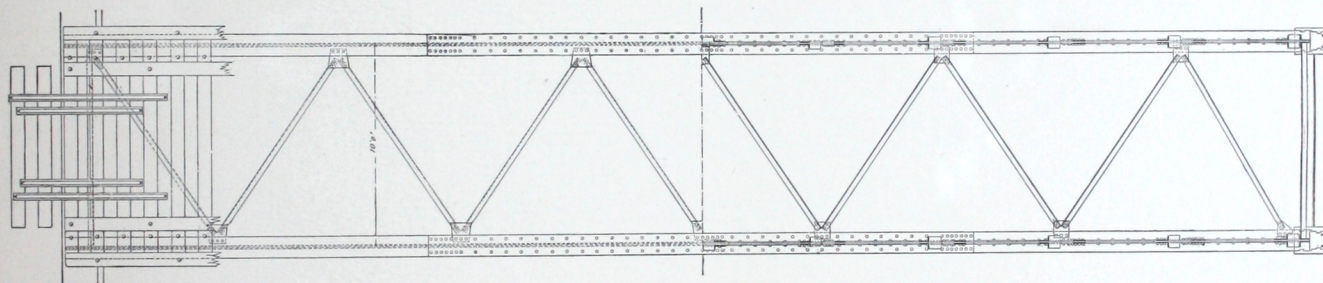
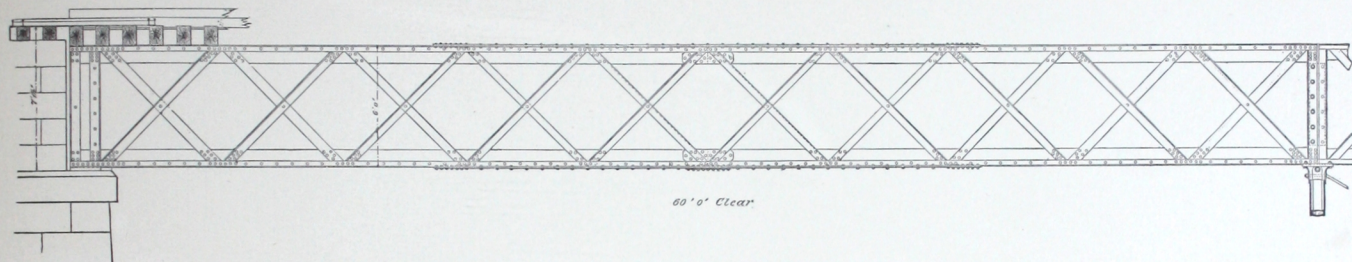
MULBERRY CREEK BRIDGE, GEORGIA, MIDLAND AND GULF RAILROAD.





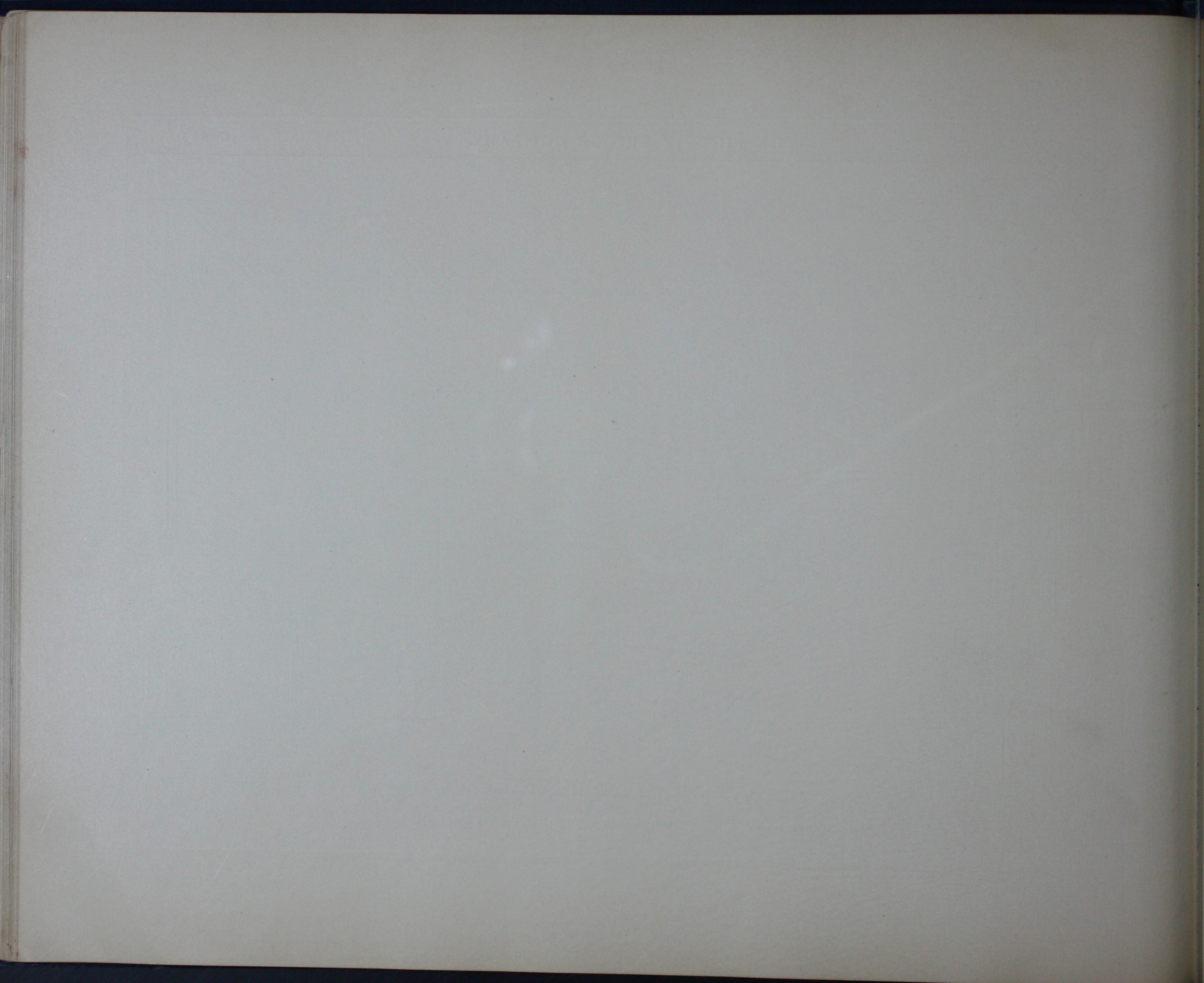
THE PHOENIX BRIDGE COMPANY.

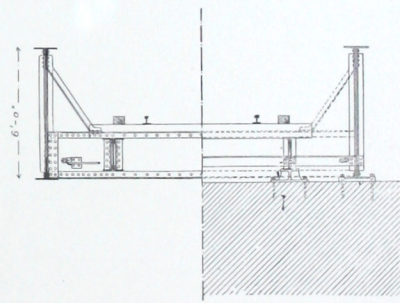
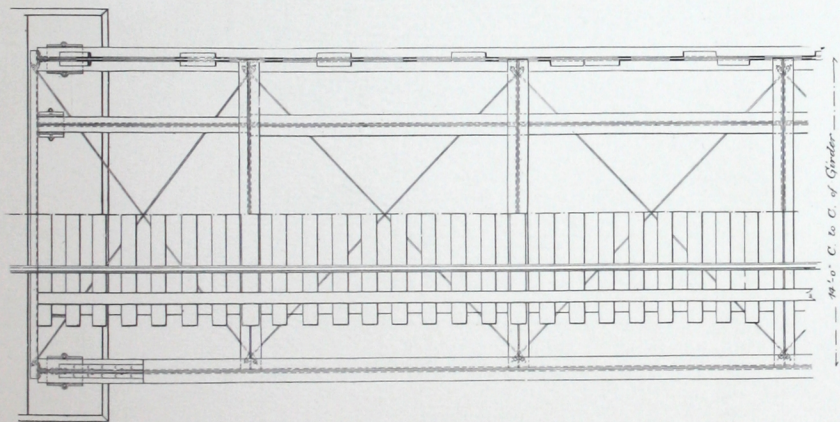
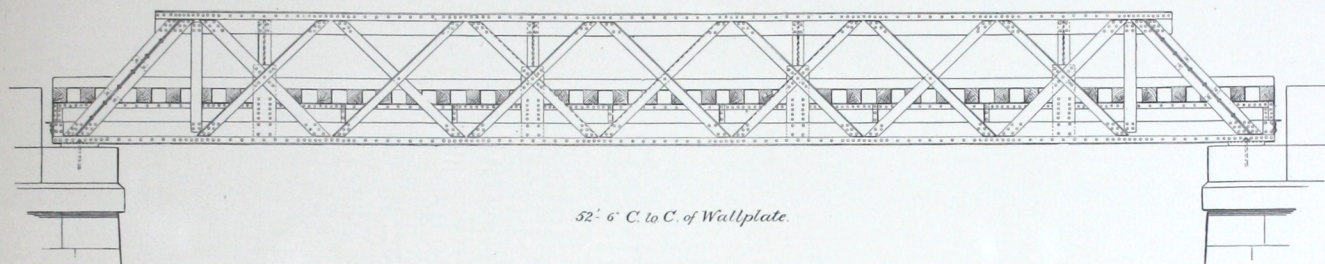
DESIGN D.



LATTICE-GIRDER SPAN.

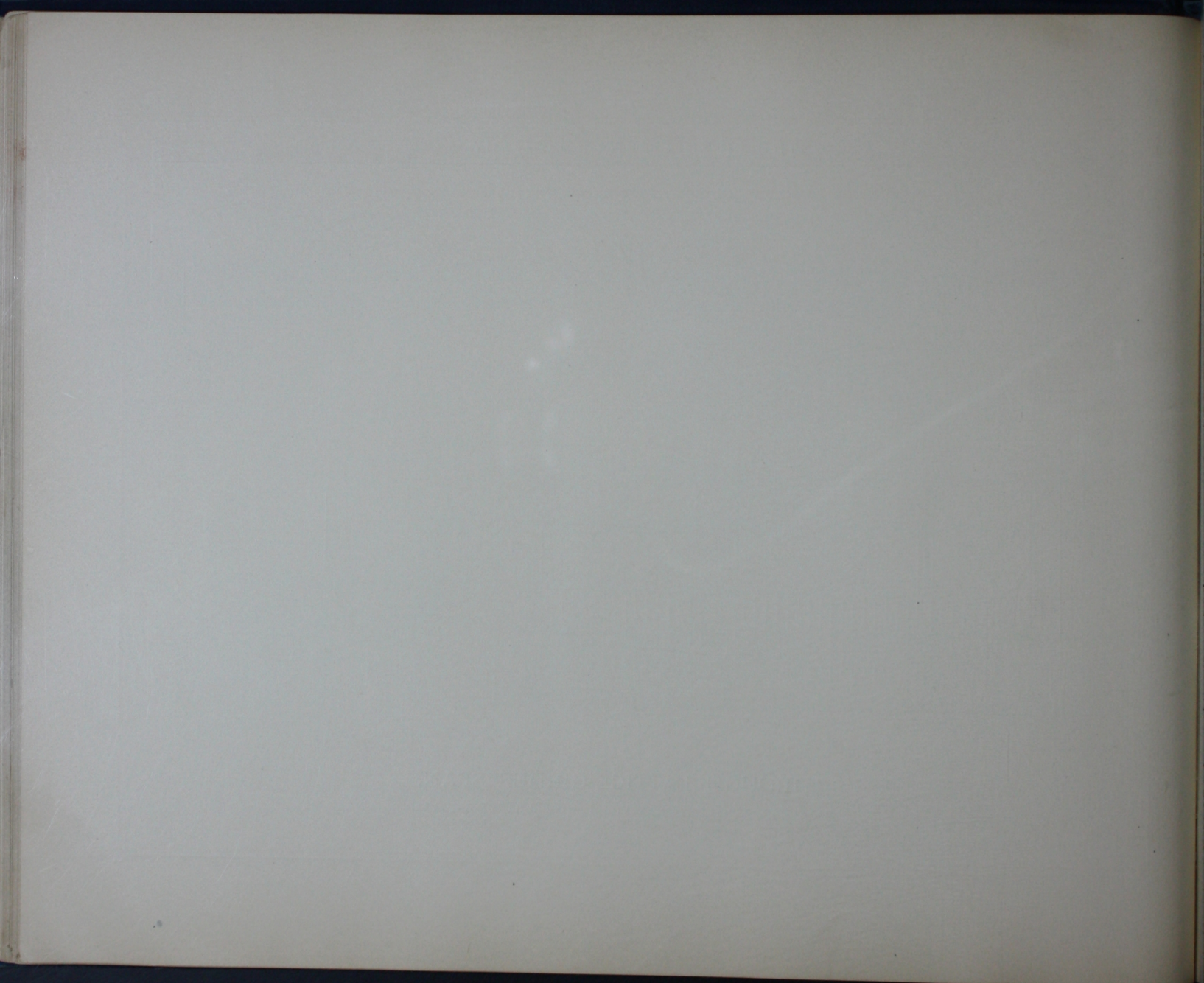
KINZUA VIADUCT. NEW YORK, LAKE ERIE AND WESTERN RAILWAY.

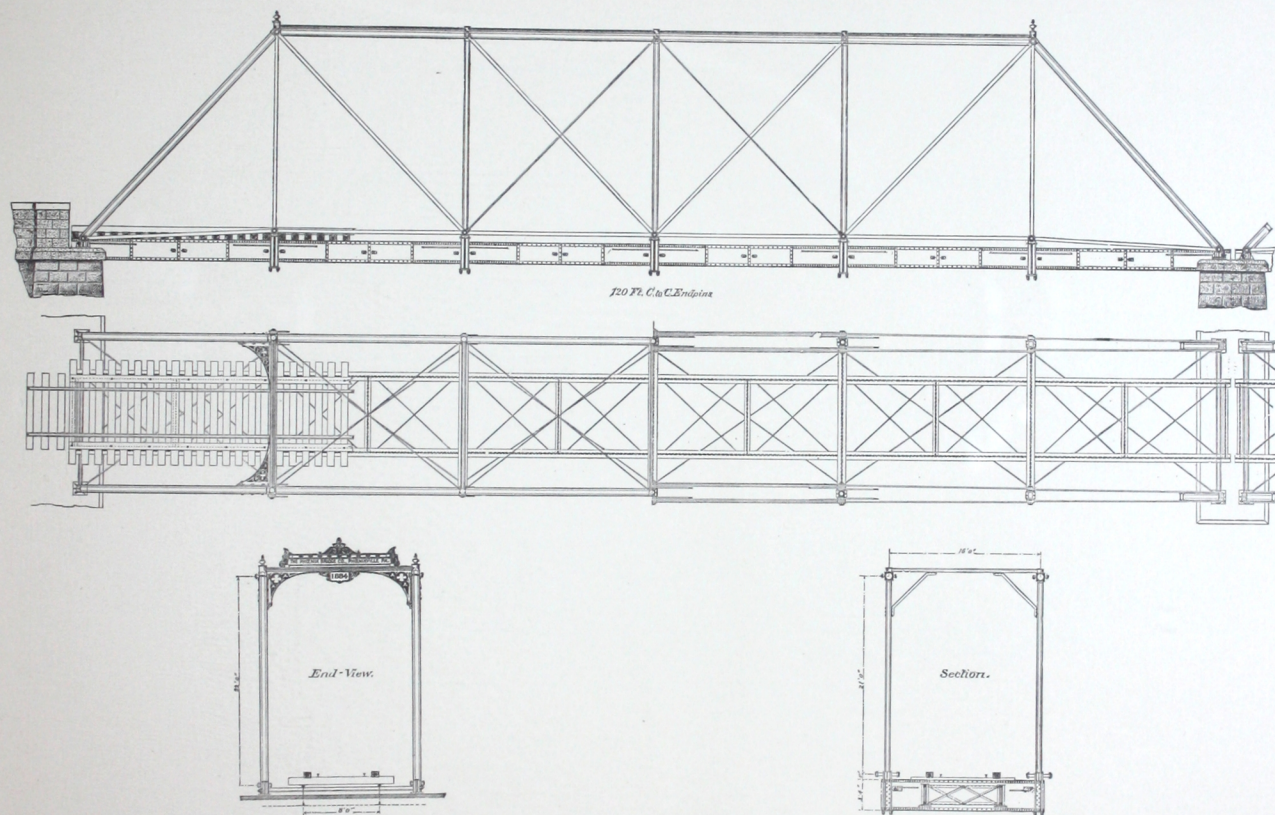




THROUGH LATTICE-GIRDER SPAN.

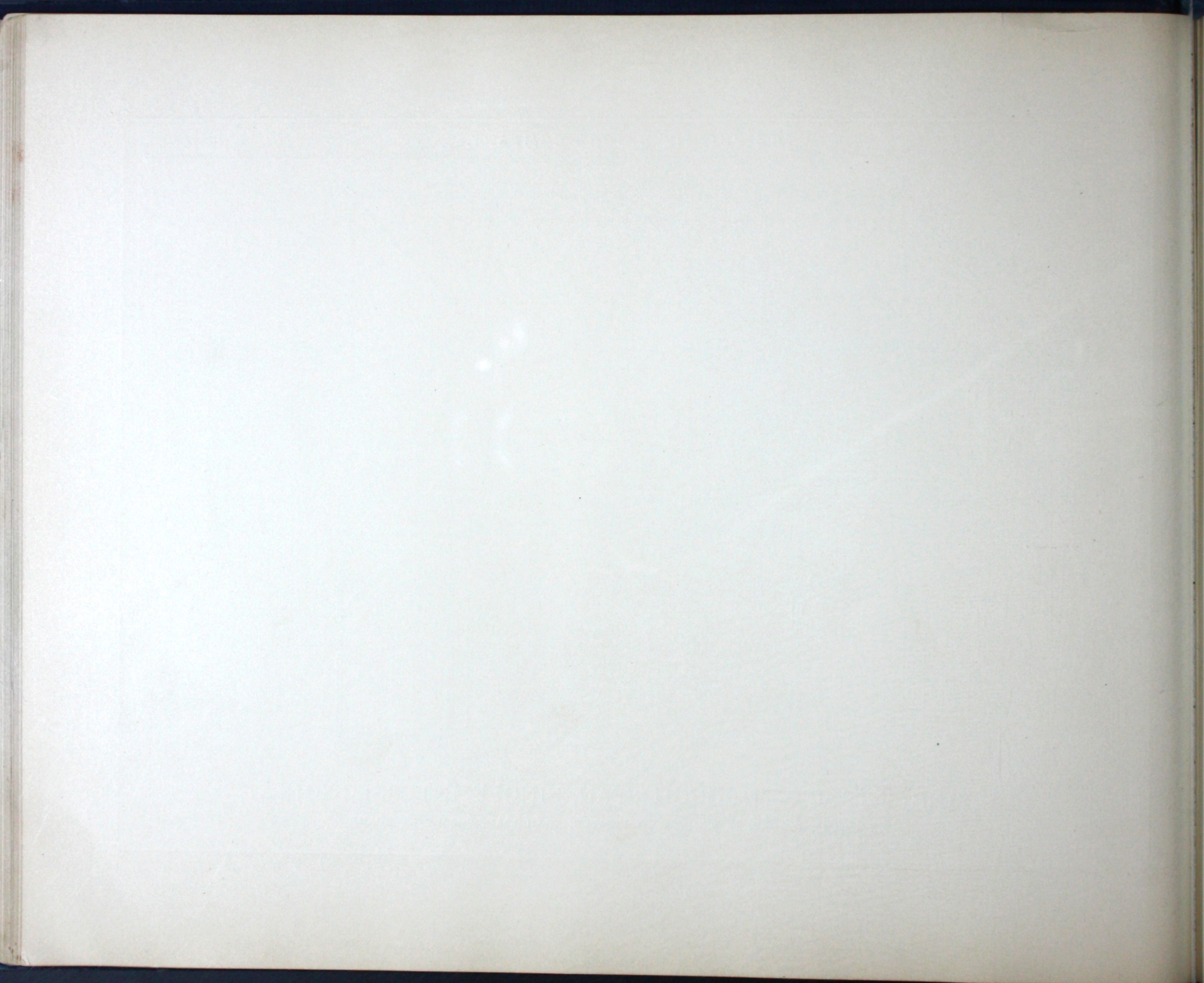
MAYSVILLE, KENTUCKY; MAYSVILLE AND BIG SANDY RAILROAD.





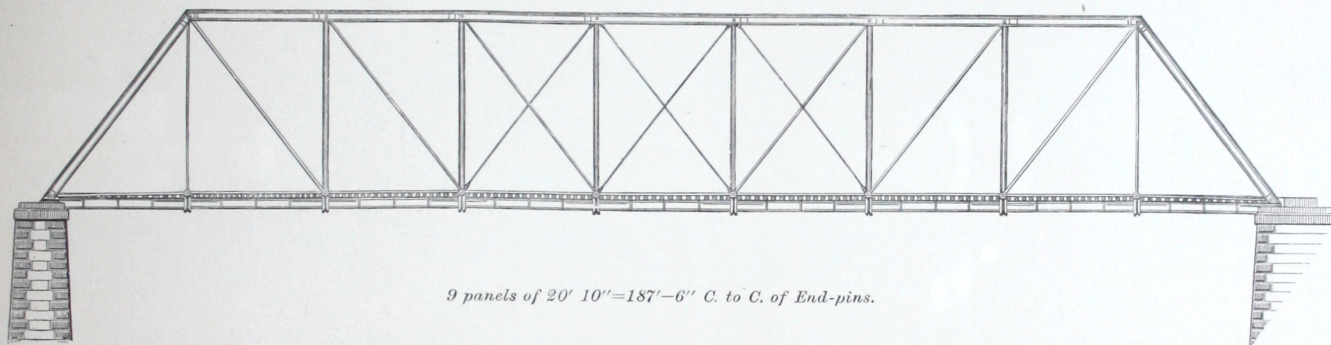
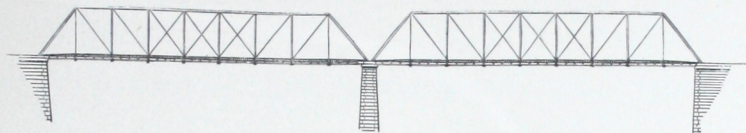
SINGLE-TRACK THROUGH SPAN, SINGLE INTERSECTION.

REED ISLAND BRIDGE, NORFOLK AND WESTERN RAILROAD, 2-120 FEET SPANS.

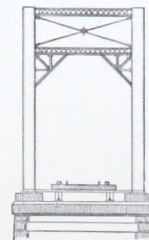
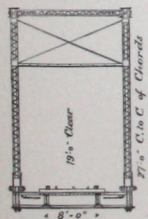
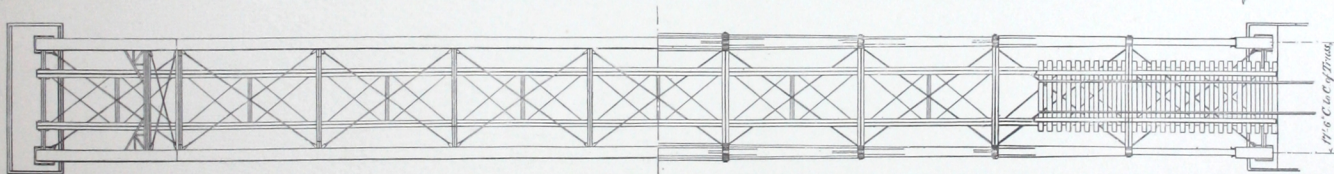


THE PHOENIX BRIDGE COMPANY.

DESIGN G.

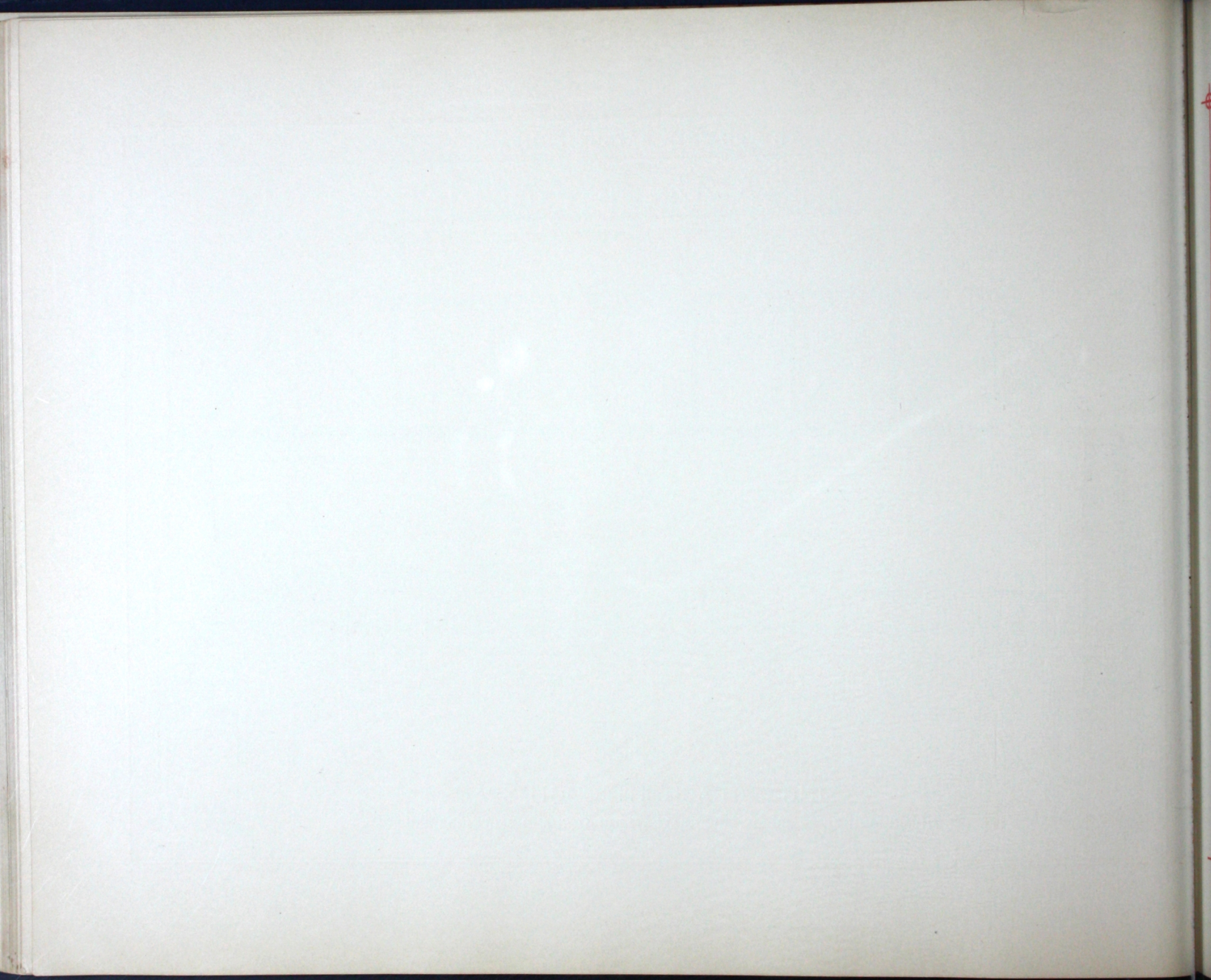


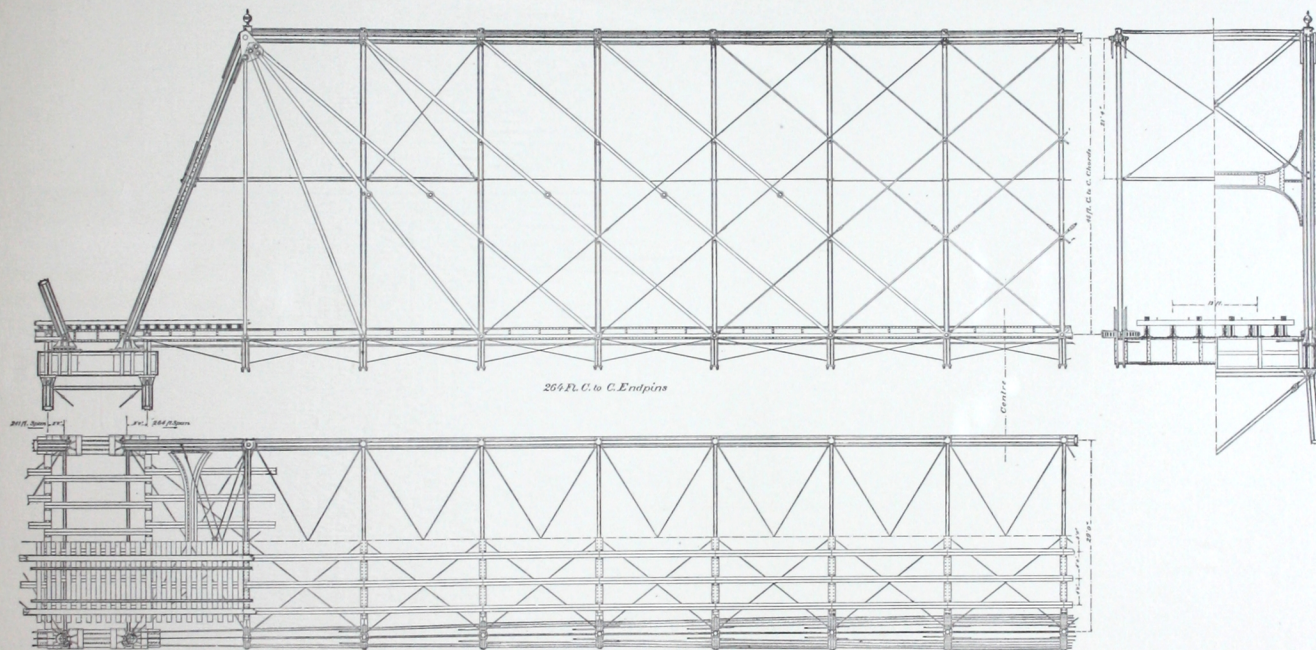
9 panels of 20' 10" = 187'-6" C. to C. of End-pins.



SINGLE-TRACK THROUGH SPAN.

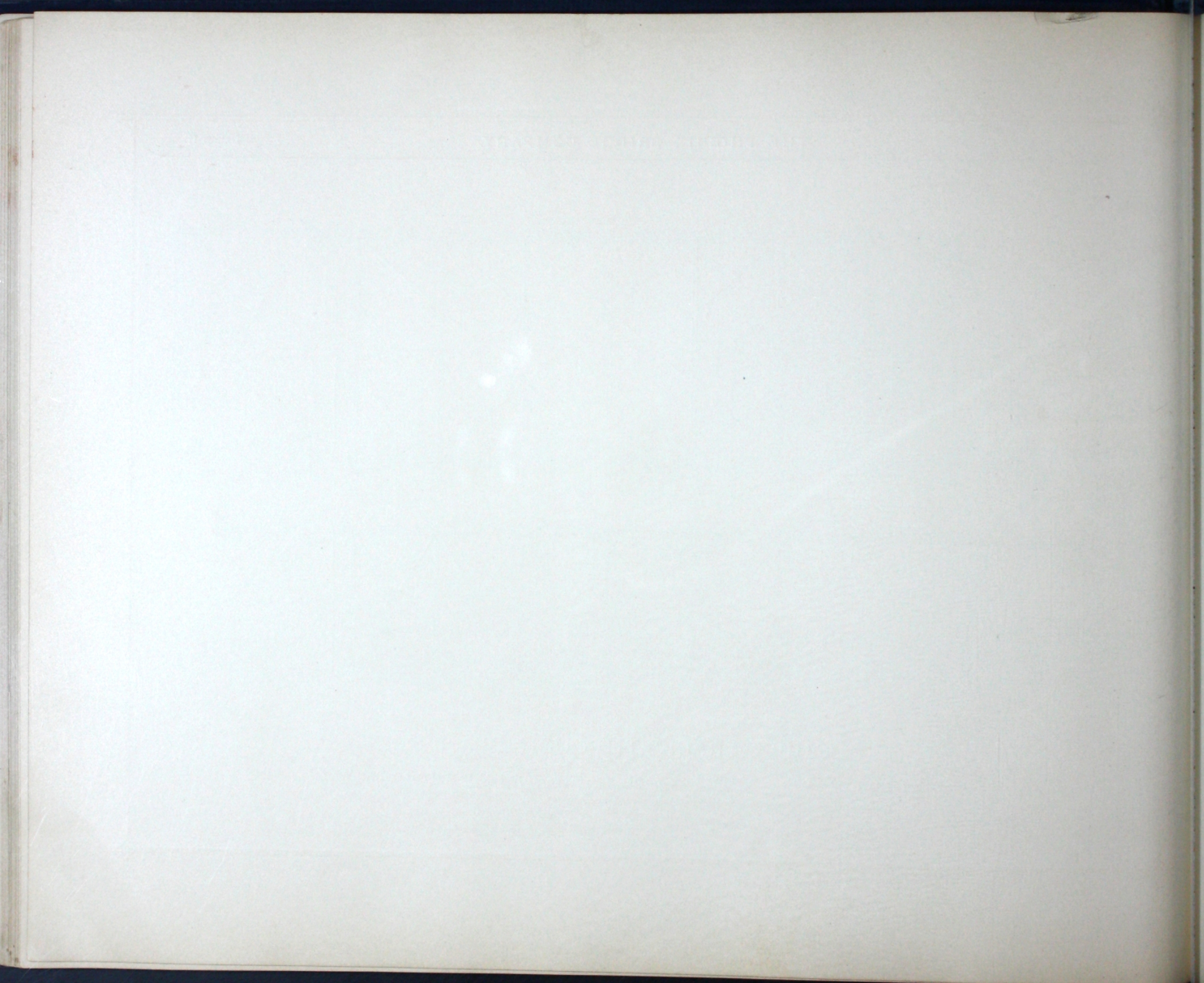
MUSKINGUM RIVER BRIDGE, CINCINNATI, WASHINGTON AND BALTIMORE RAILROAD.





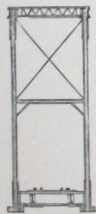
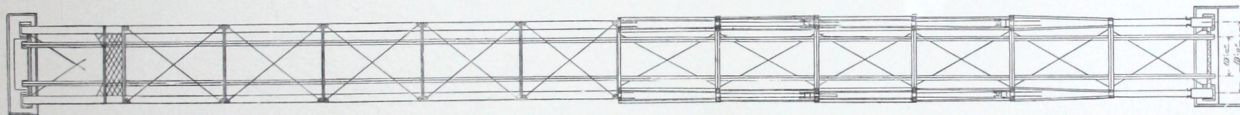
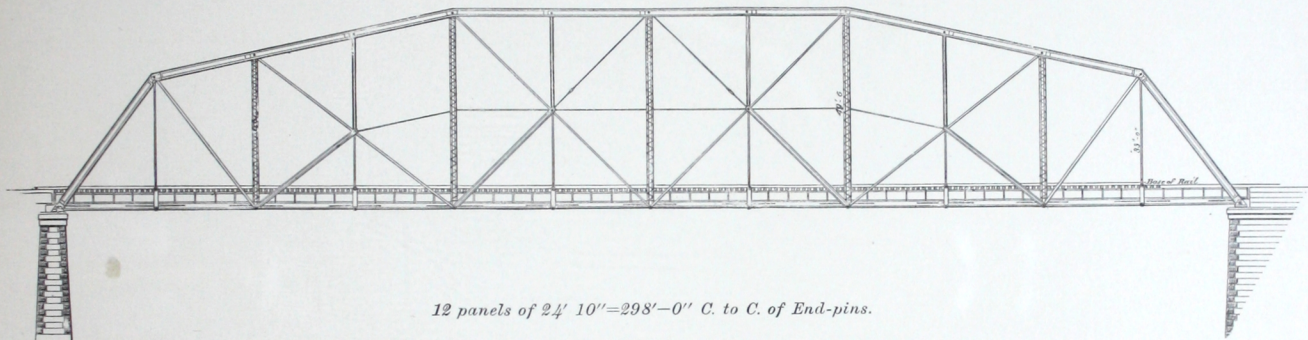
DOUBLE-TRACK THROUGH SPAN.

264 FEET SPAN OF RONDOUT BRIDGE, NEW YORK, WEST SHORE AND BUFFALO RAILWAY.



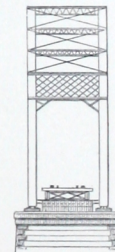
THE PHOENIX BRIDGE COMPANY.

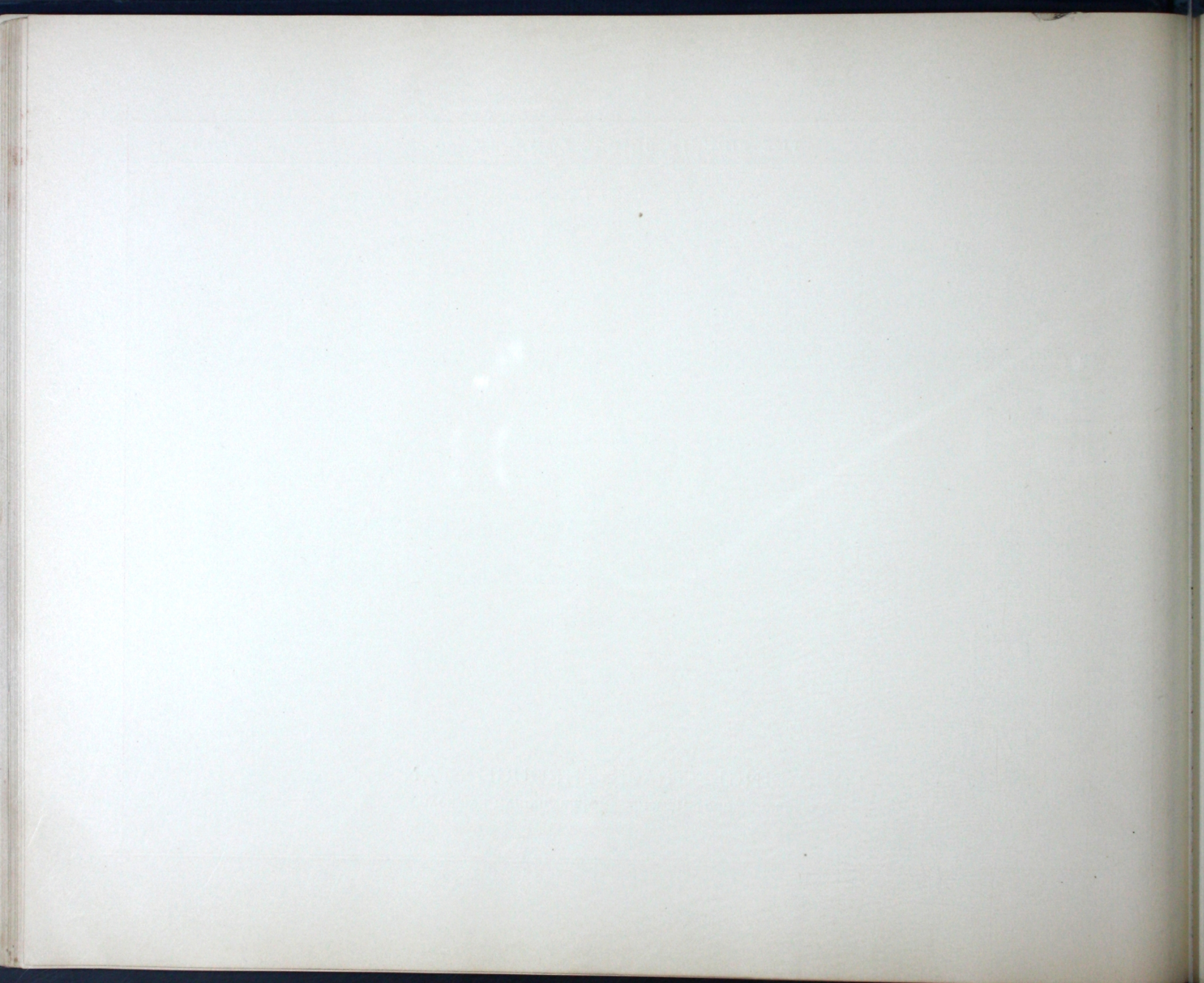
DESIGN I.



LONG SINGLE-TRACK THROUGH SPAN.

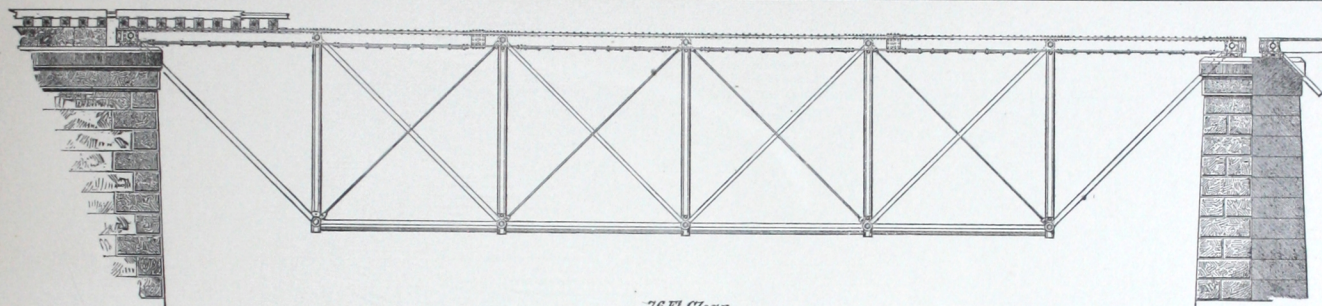
BIG WARRIOR BRIDGE, MEMPHIS AND BIRMINGHAM RAILROAD.



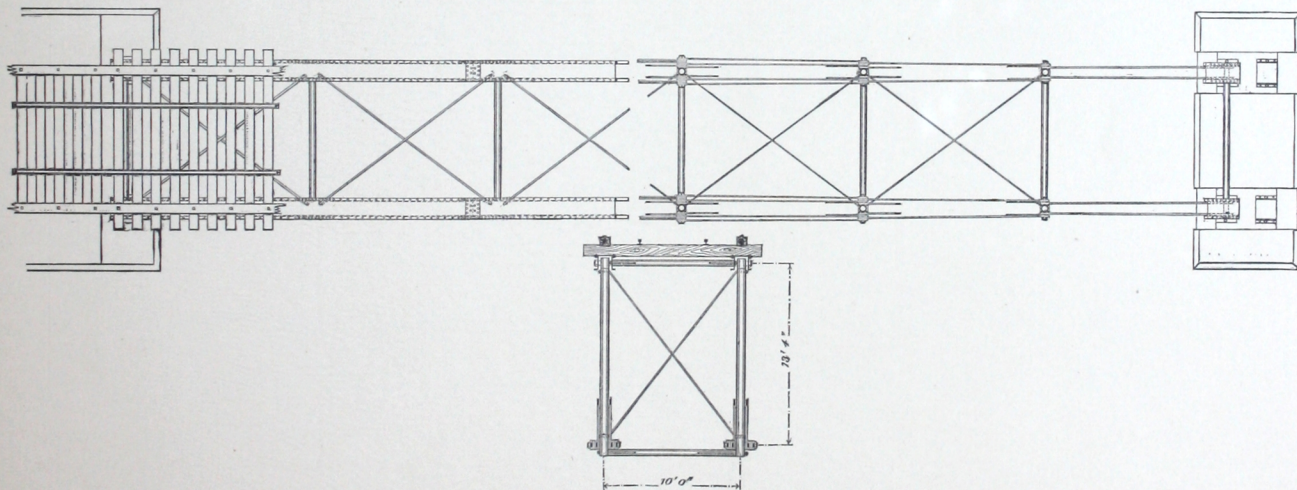


THE PHOENIX BRIDGE COMPANY.

DESIGN K.



76 Ft. Clear,



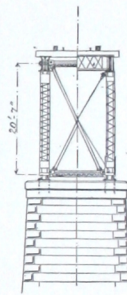
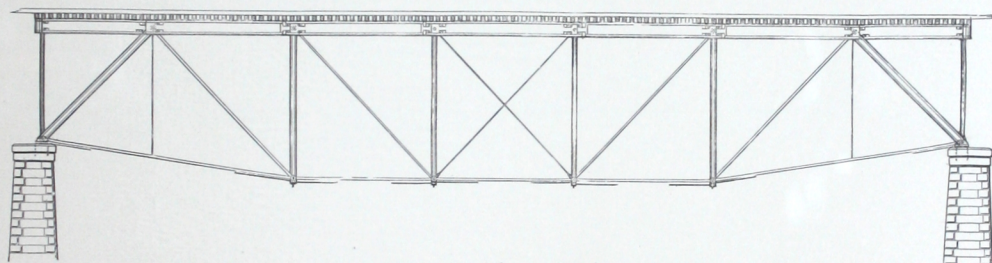
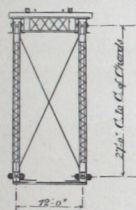
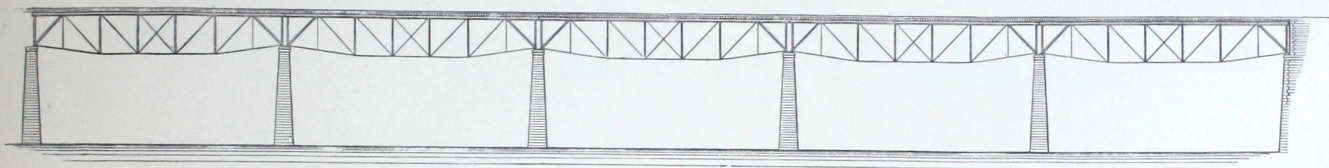
SINGLE-TRACK DECK-SPAN.

DUNLAP'S CREEK BRIDGE, CHESAPEAKE AND OHIO RAILWAY.

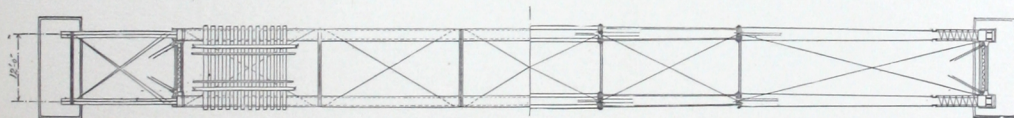


THE PHOENIX BRIDGE COMPANY.

DESIGN L.

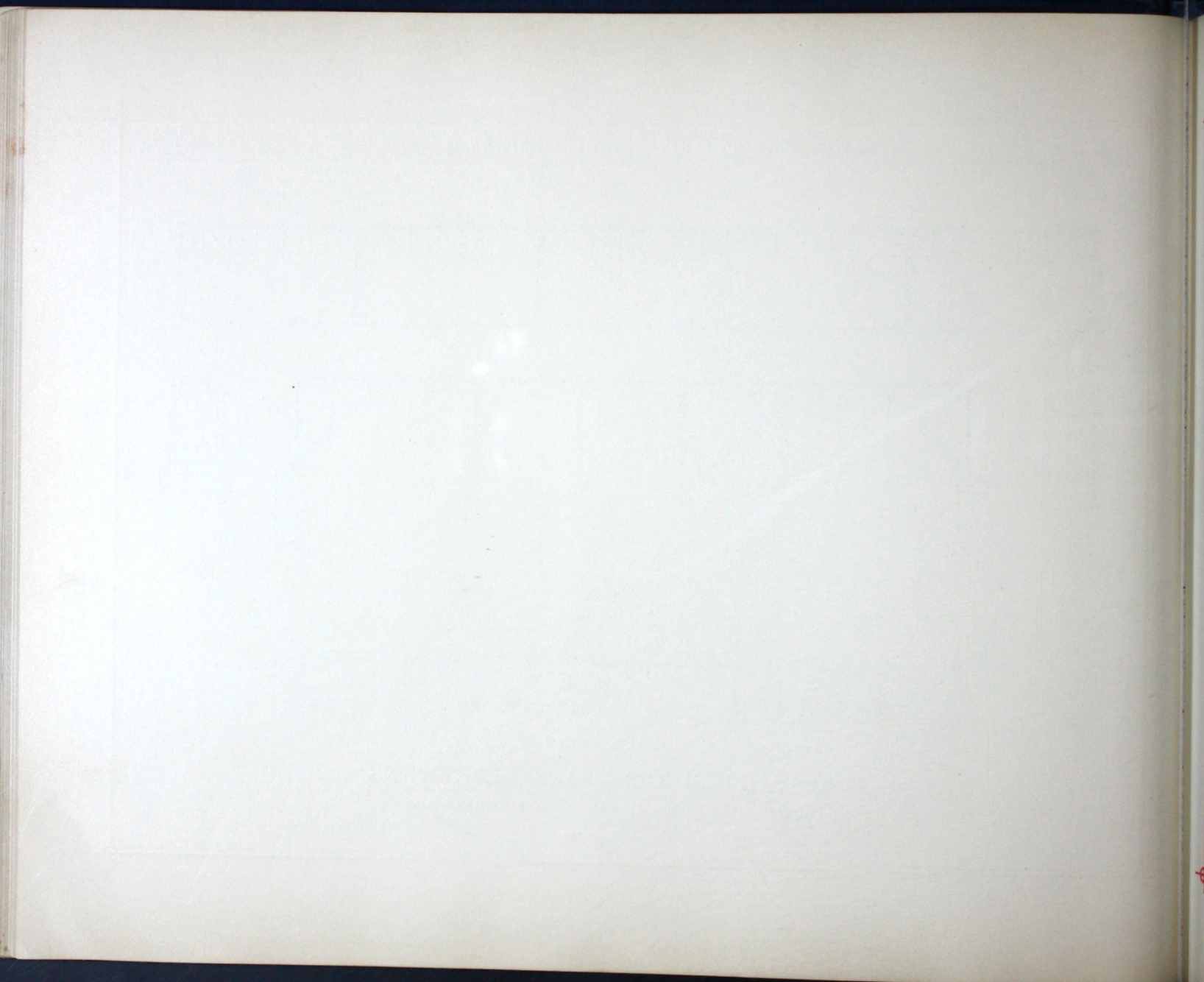


164'-0" C. to C. of Endpins.



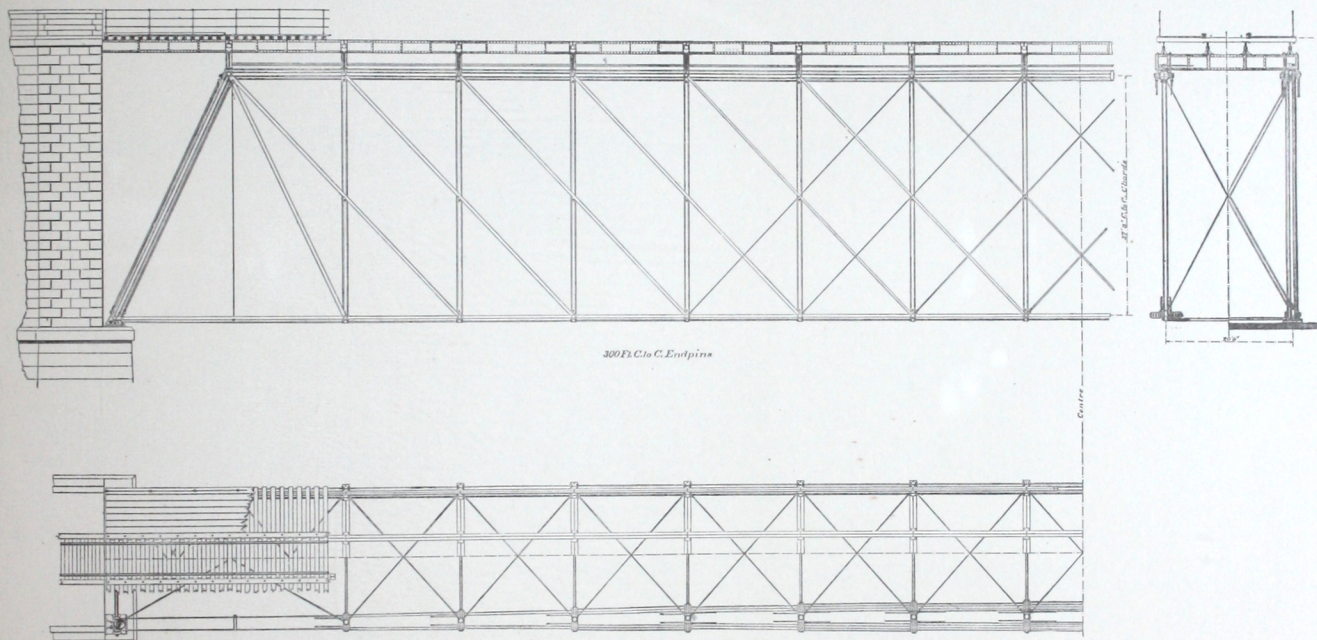
LONG PANEL SINGLE-TRACK DECK-SPANS.

POTOMAC RIVER BRIDGE, SHENANDOAH VALLEY RAILROAD.



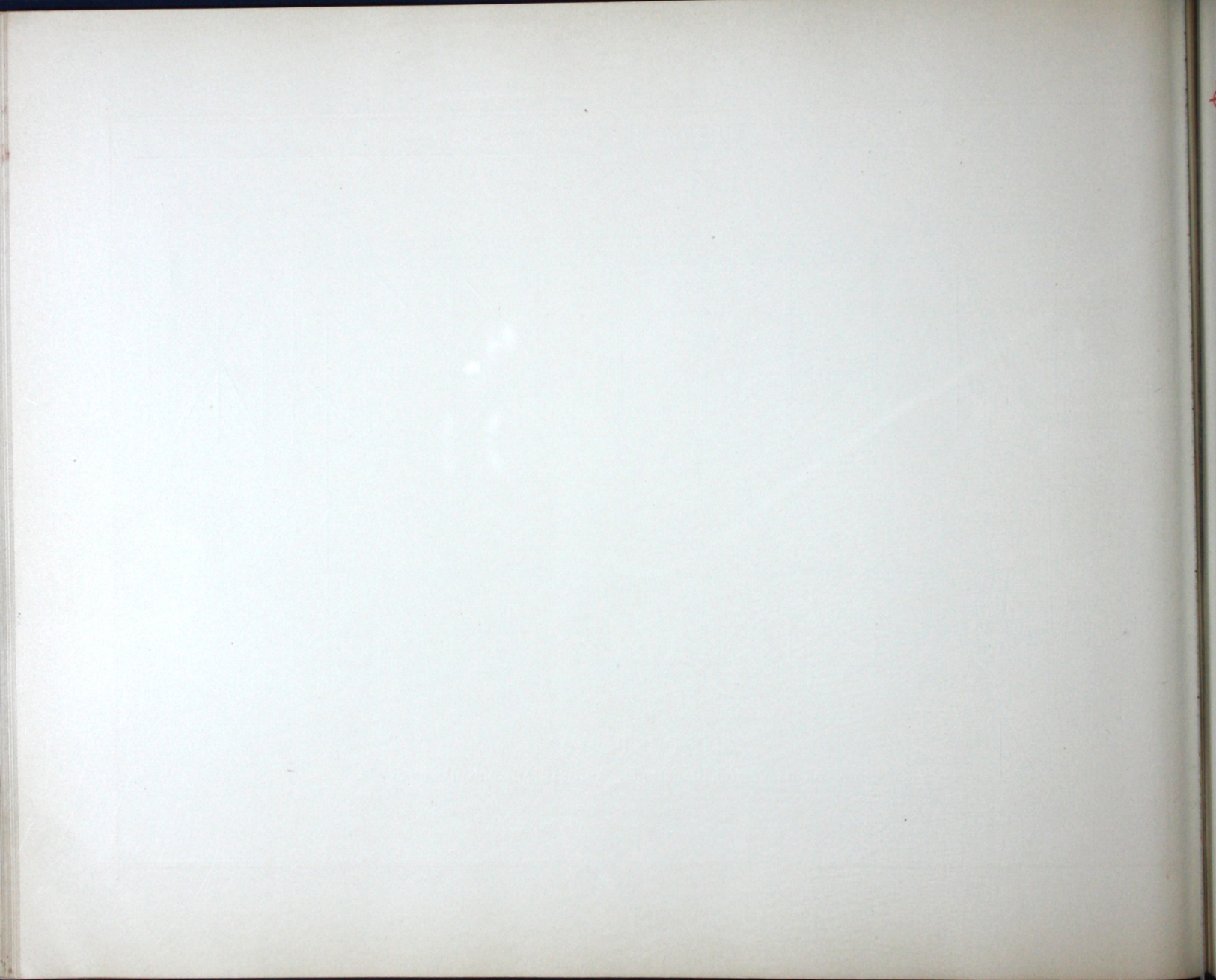
THE PHOENIX BRIDGE COMPANY.

DESIGN M.



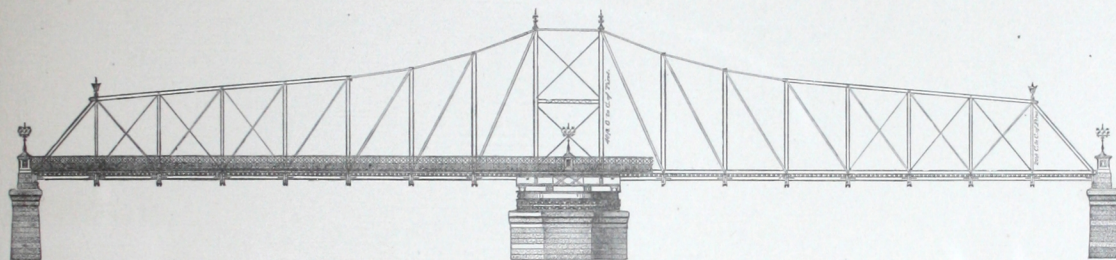
300 FEET SPAN.

BUILT FOR GALVESTON, HARRISBURG AND SAN ANTONIO RAILROAD.

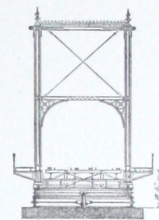


THE PHOENIX BRIDGE COMPANY.

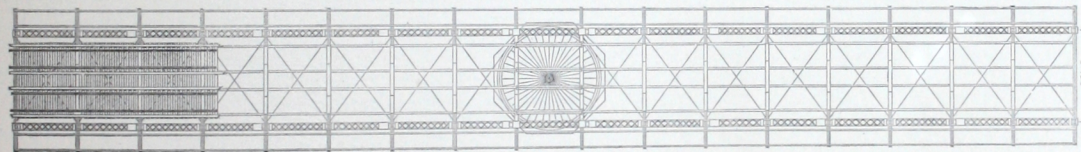
DESIGN N.



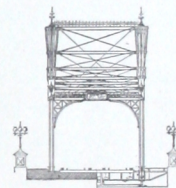
297'-4 1/2" O. to C. of Entropins



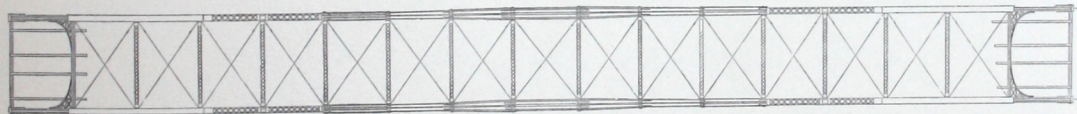
Section at Centre.



Plan of Floor system and Lower Lateral Bracing.



End View.

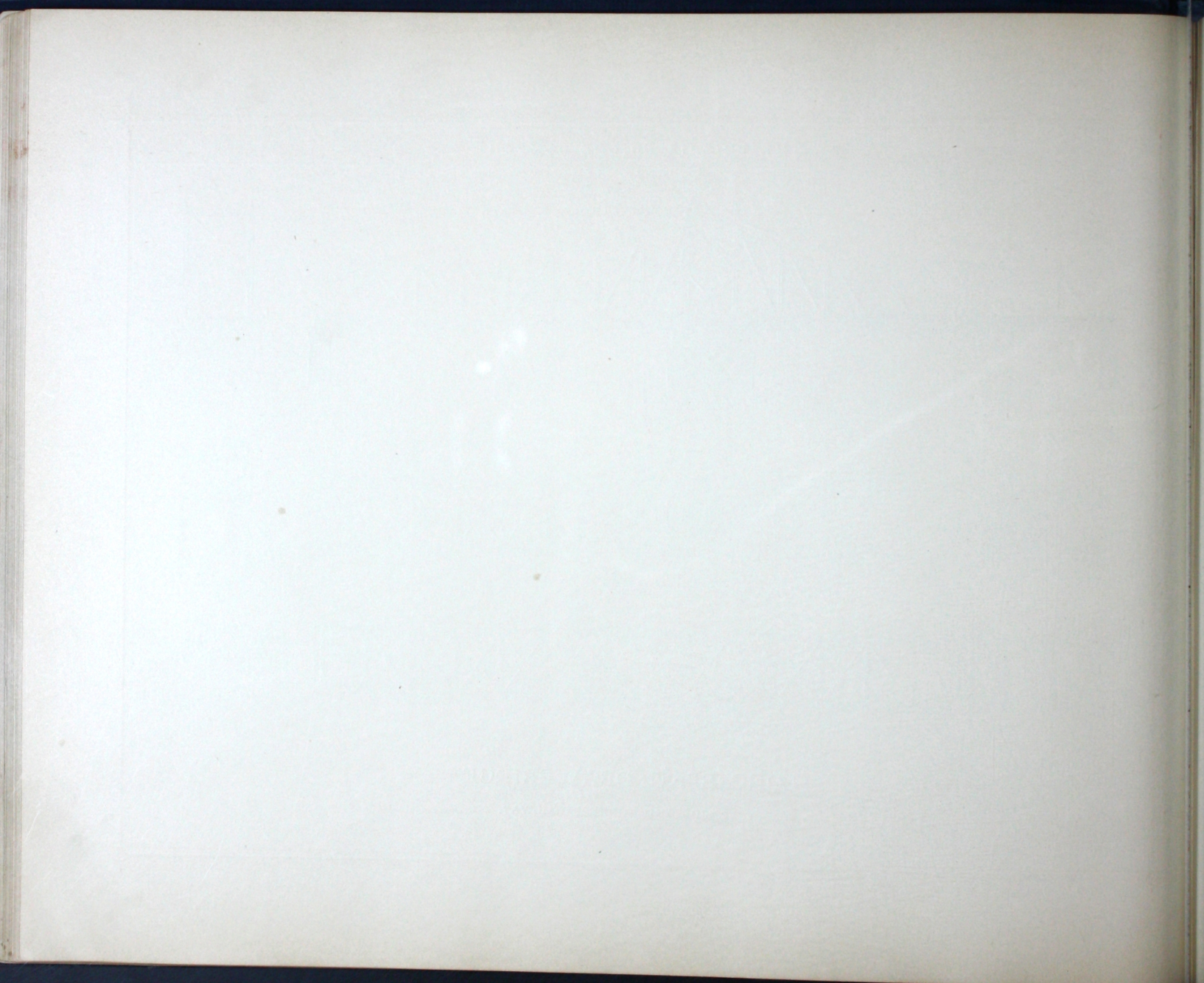


Plan of Upper Lateral Bracing.

Design H.
297 Ft. Double-Track-
Draw Bridge.

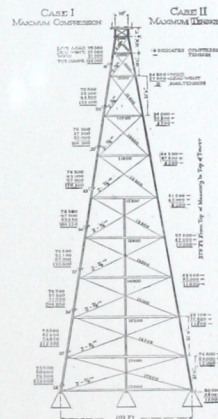
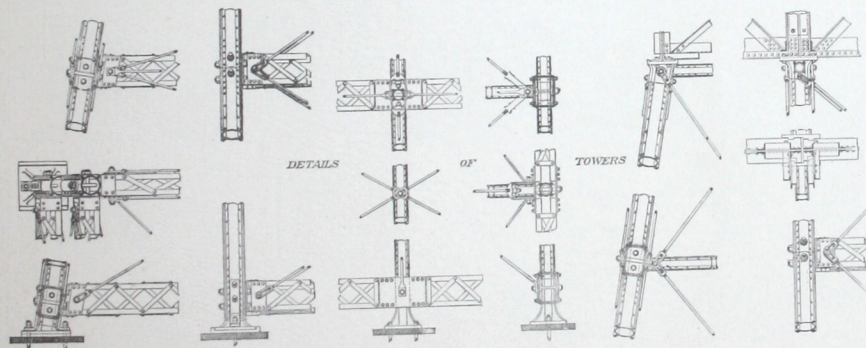
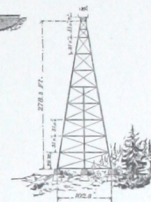
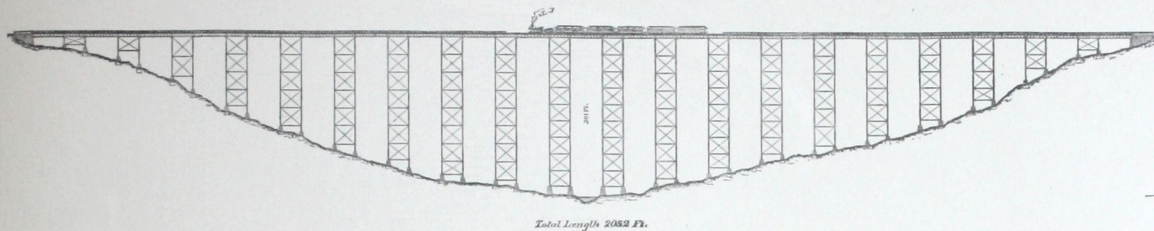
LONG SPAN DRAWBRIDGE.

WEST SIDE AND YONKERS RAILWAY.



THE PHOENIX BRIDGE COMPANY.

DESIGN O.



DATA FOR STRESSES.

Live Load: Consolidation engines having 80,000 lbs. on drivers in a space of 14 ft. 9 in. Total weight of engine and tender, 101,340 lbs. Length over all, 51 ft. 3 in.

Dead Load: 1000 lbs. per lin. ft.

CASE I.
Gives maximum compression. Structure loaded. Wind-pressure 30 lbs. per sq. ft. Wind-pressure at top, 20,000 lbs.; on each story, 64 lbs. per vertical ft., or 1950 lbs. per story.

CASE II.
Gives maximum tension. Structure unloaded. Wind-pressure at top, 15,000 lbs.; on each story, 100 lbs. per vertical ft., or 3300 lbs. per story.

Stresses in diagonal and struts are the maxima which can arise from either case.

All longitudinal rods, $\frac{7}{8}$ in.—2 rods.

All struts (except S_1, S_2, S_3) of 4 angles, $2\frac{1}{2} \times 2\frac{1}{2} \times 15$ lbs. per yard laced.

S_1, S_2, S_3 of B' column. Area, 6 sq. in.

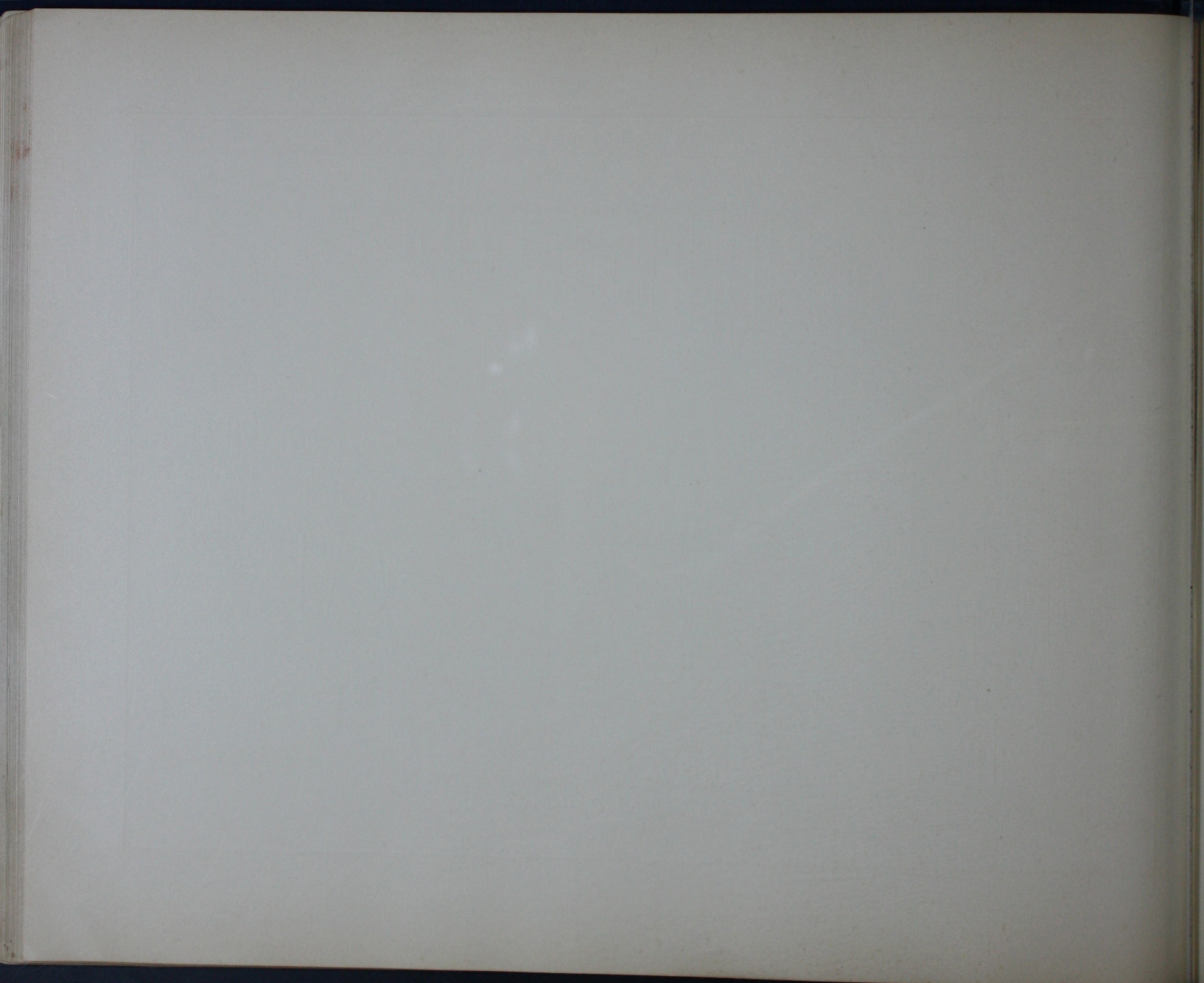
Ultimate strength of Phoenix columns, 35,000 lbs. per sq. in., as per experiments at United States Arsenal, Waterville, Me.

Factor of safety for live and dead loads—5, equivalent to 7000 lbs. per sq. inch.

Factor of safety for wind-pressure, $\frac{3}{2}$, equivalent to 10,000 lbs. per sq. inch. Diagonals strained 15,000 lbs. per sq. inch.

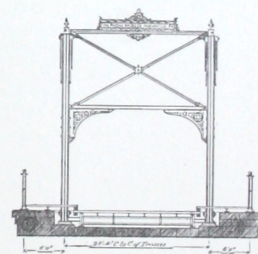
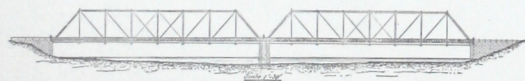
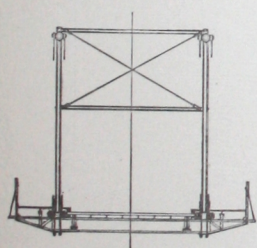
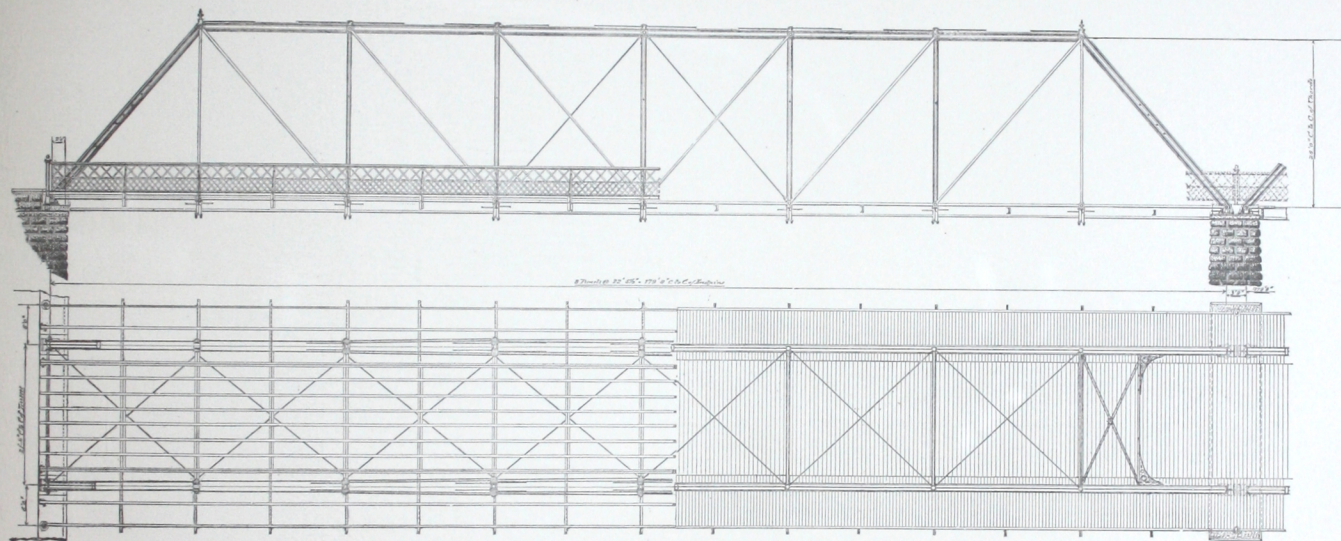
KINZUA VIADUCT.

NEW YORK, LAKE ERIE AND WESTERN RAILWAY.



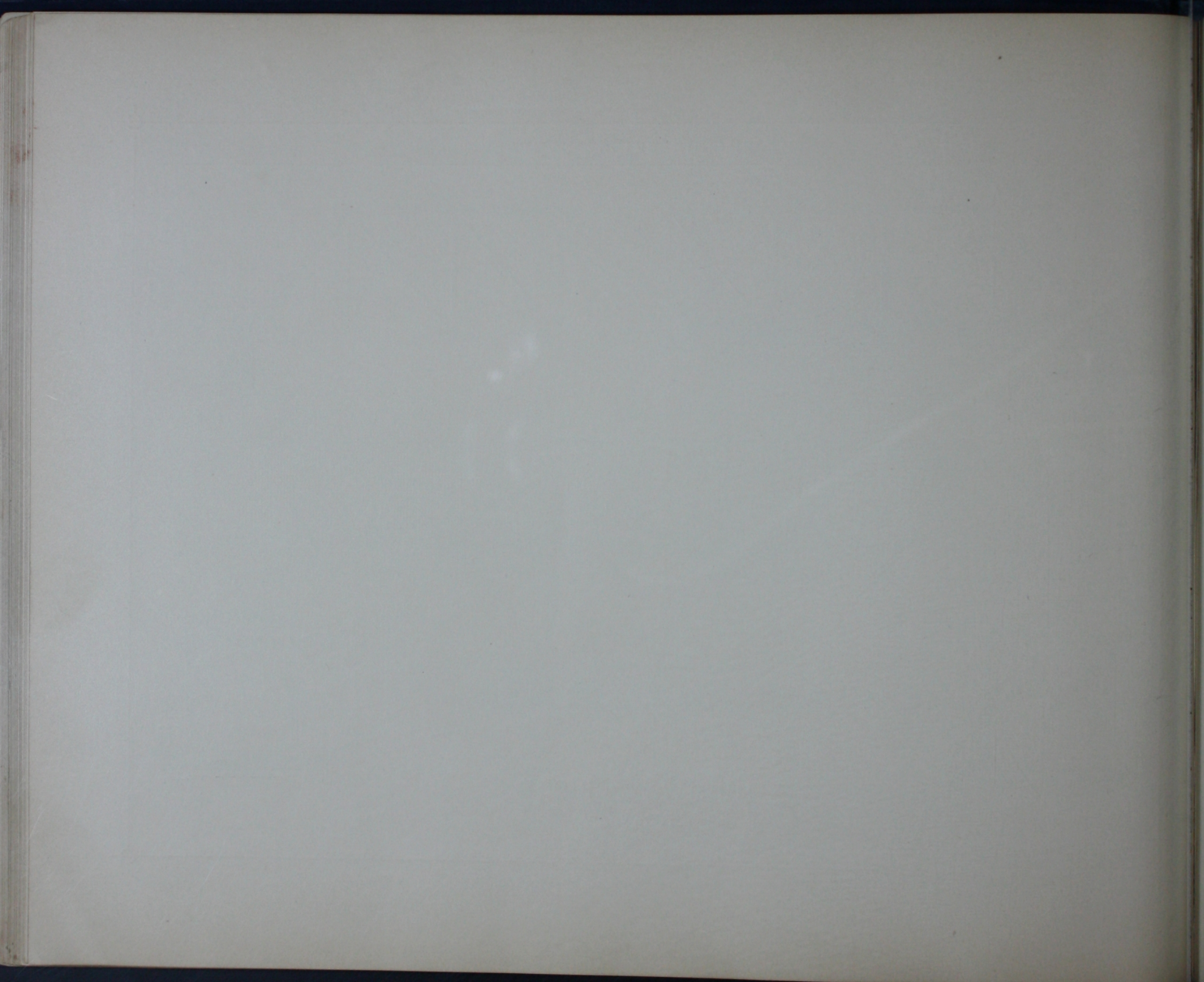
THE PHOENIX BRIDGE COMPANY.

DESIGN P.



HIGHWAY BRIDGE,

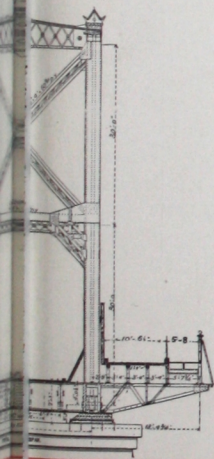
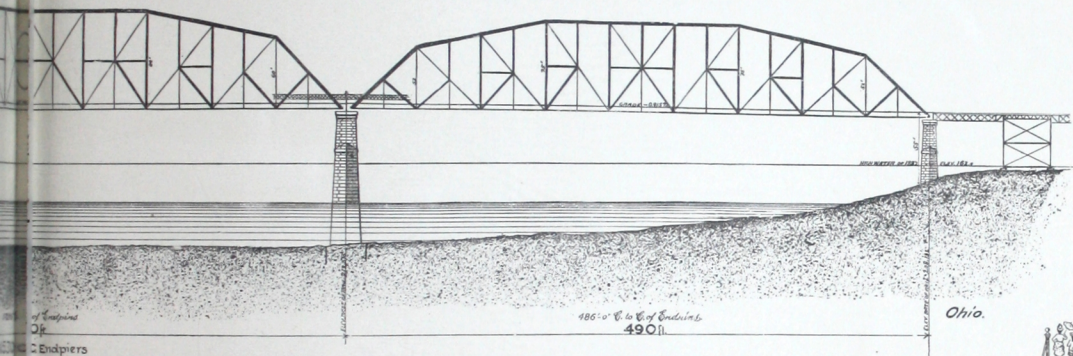
POTTSTOWN, PA.



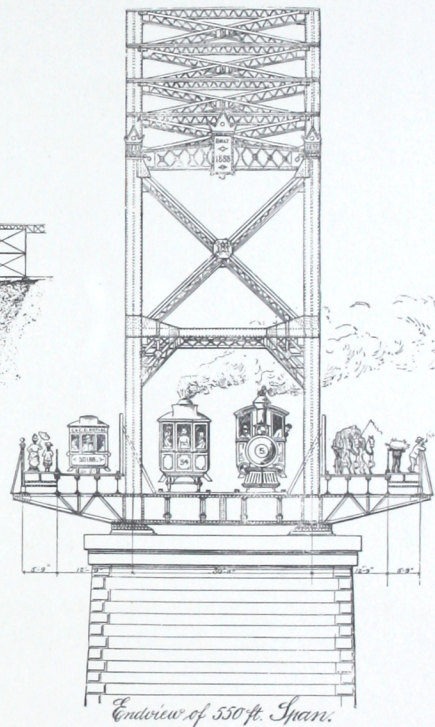


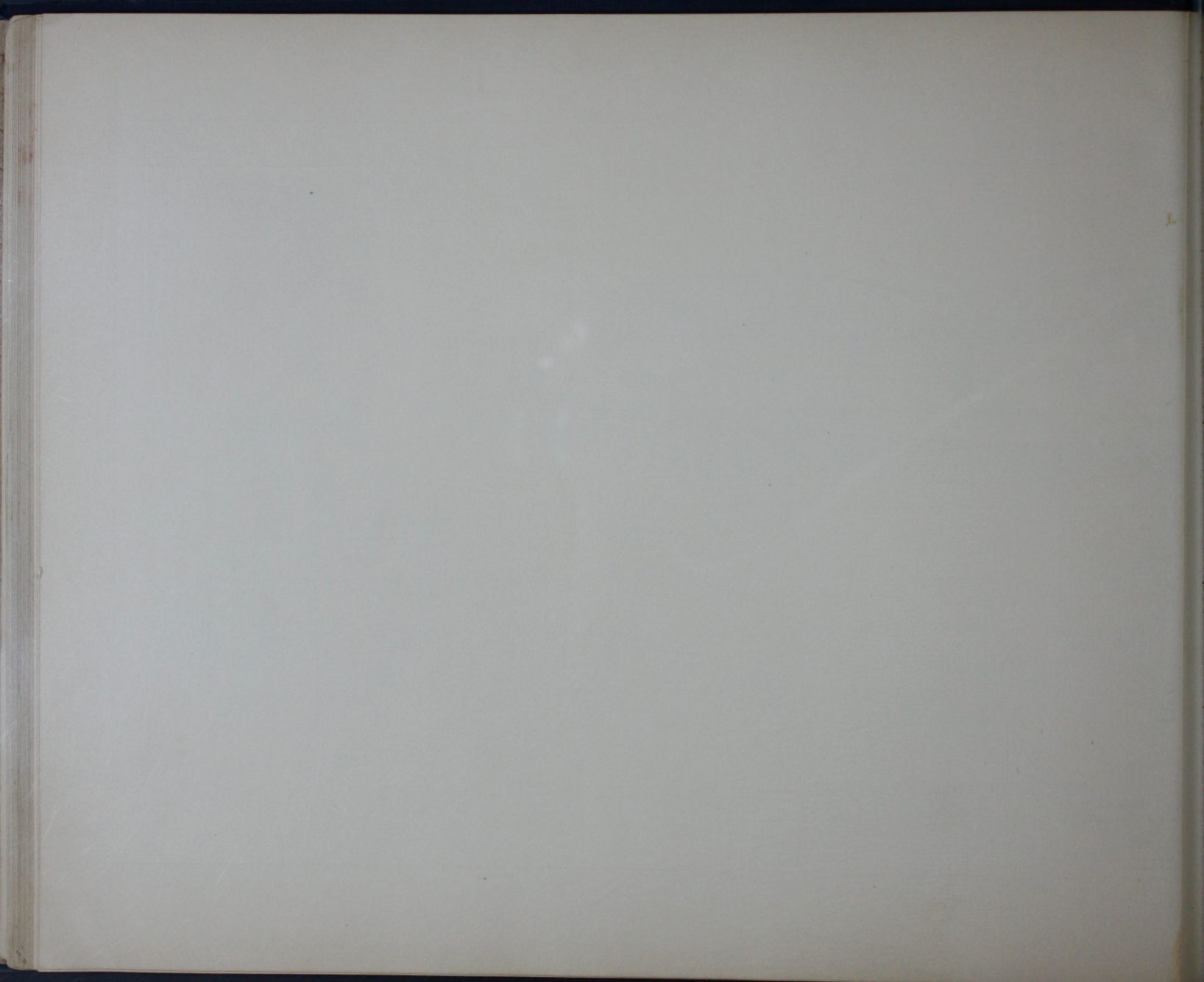
BRIDGE COMPANY.

DESIGN R.

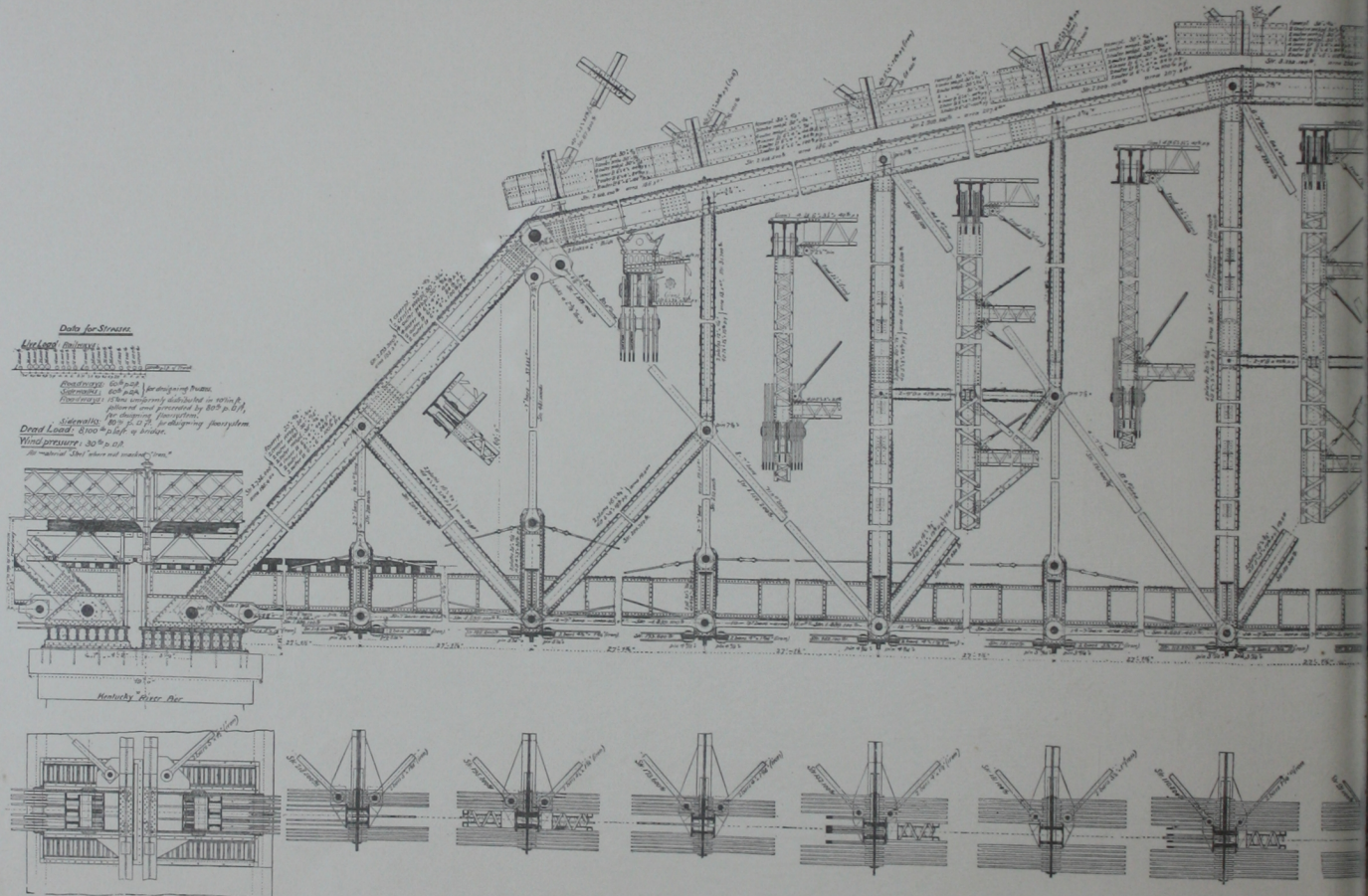


DESIGNED, CONSTRUCTED, AND ERECTED
BY
THE PHOENIX BRIDGE CO.,
Engineers and Contractors,
PHILADELPHIA, PA.,
1888.



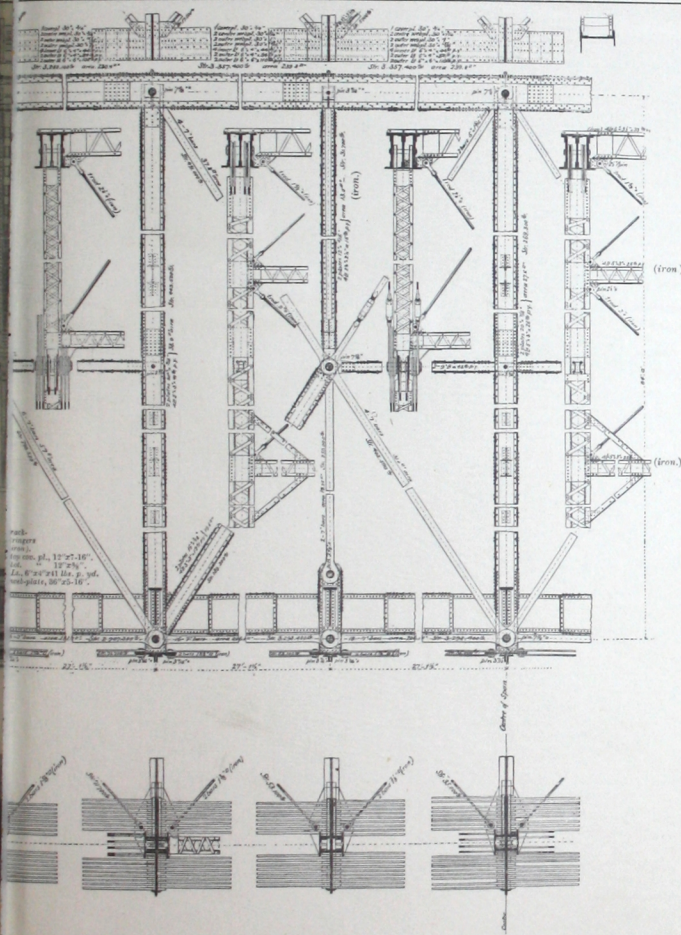






BRIDGE COMPANY.

DESIGN S.



GENERAL PLAN.

ONE 550' 0" THROUGH SPAN—OHIO RIVER BRIDGE.

THE COVINGTON AND CINCINNATI ELEVATED RAILROAD
AND TRANSFER AND BRIDGE CO.

DESIGNED, CONSTRUCTED, AND ERECTED BY

THE PHOENIX BRIDGE COMPANY,

Engineers and Contractors,

PHILADELPHIA, PA.,

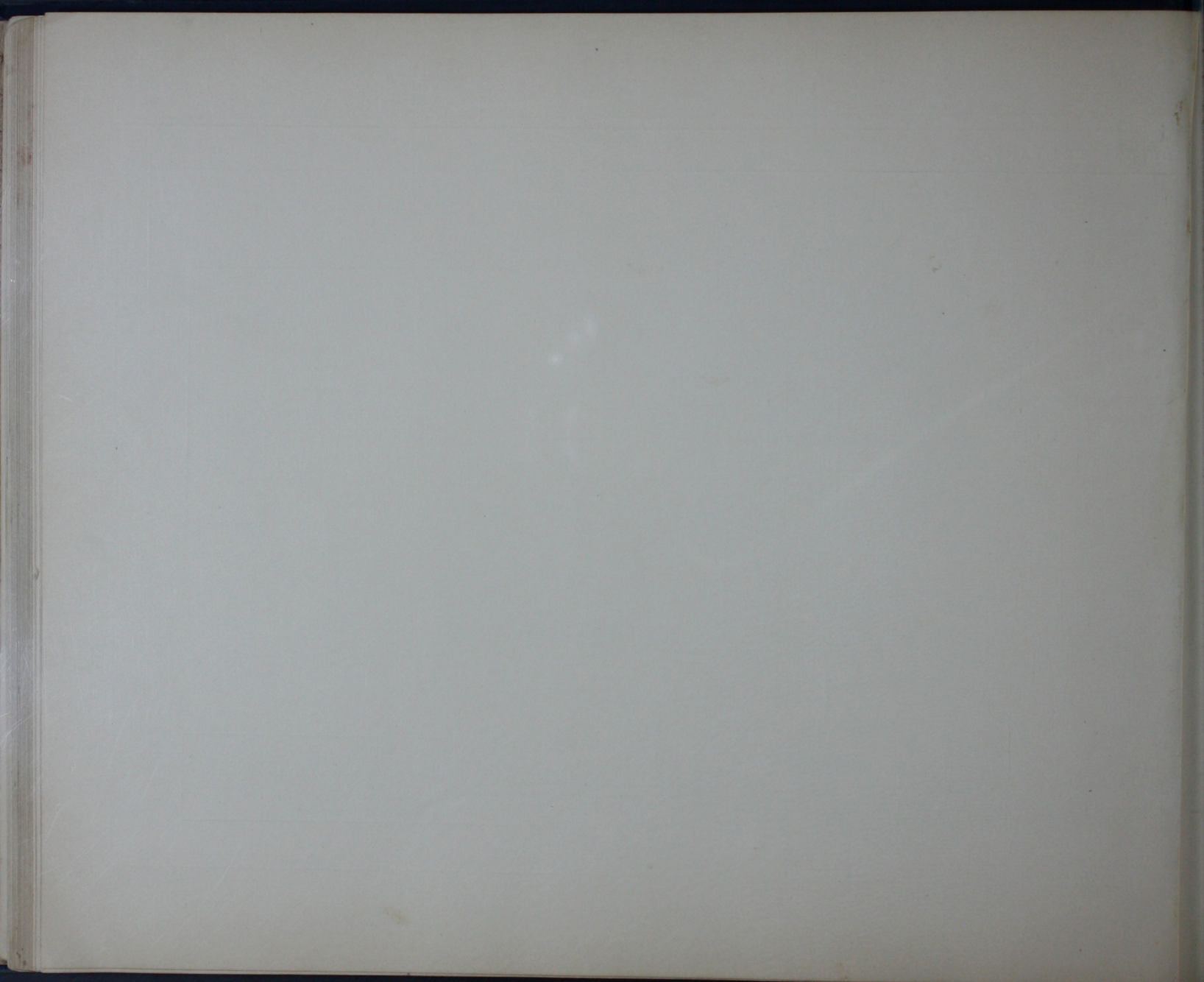
1888.

DOUBLE-TRACK RAILWAY. TWO ROADWAYS. TWO SIDEWALKS.

ARRANGEMENT OF BOTTOM CHORD FOR

ONE 550' 0" THROUGH SPAN—OHIO RIVER BRIDGE.

THE COVINGTON AND CINCINNATI ELEVATED RAILROAD
AND TRANSFER AND BRIDGE CO.



PLATES

SHOWING

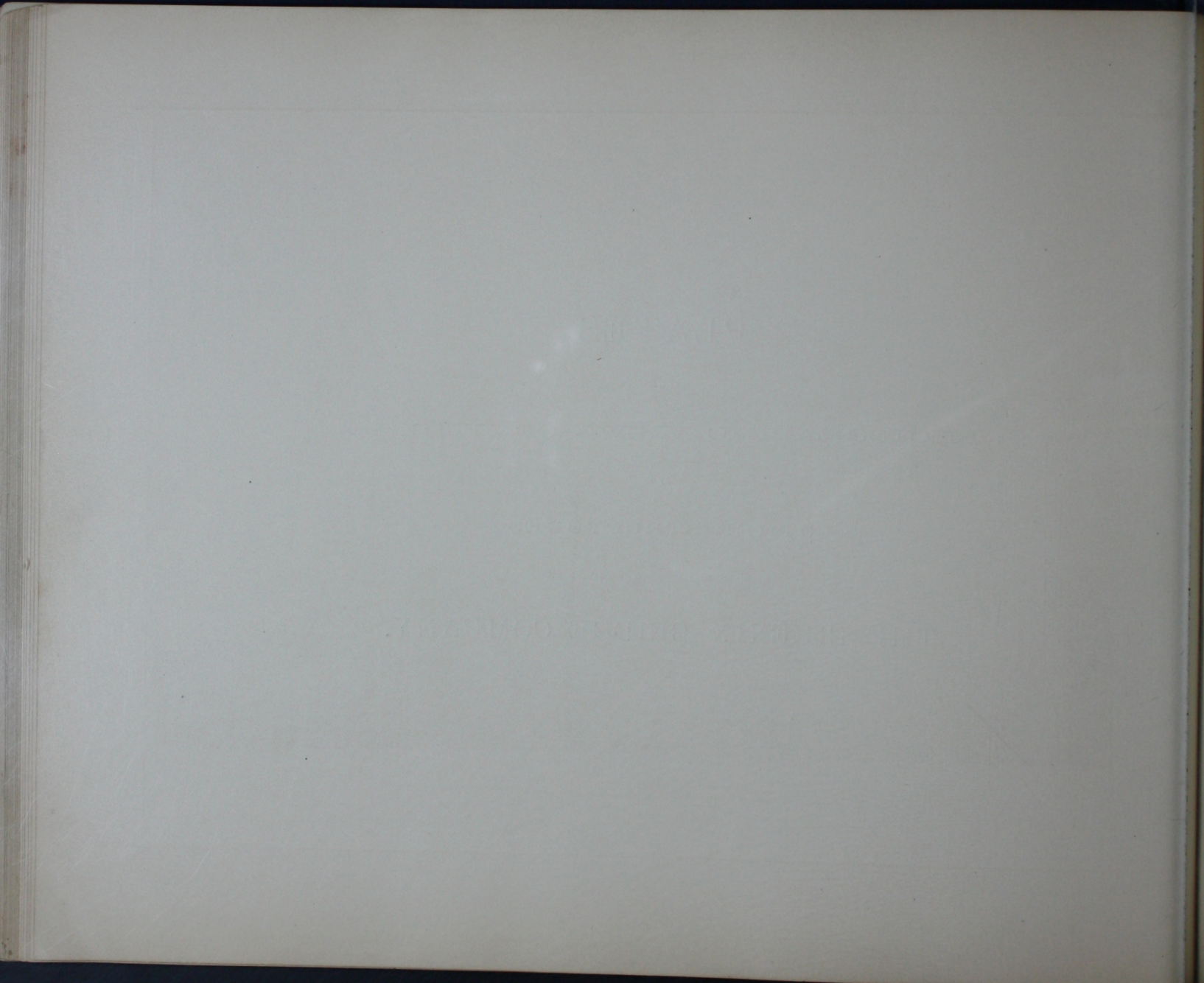
PHOTOGRAPHIC VIEWS OF BRIDGES

AND

—OTHER STRUCTURES—

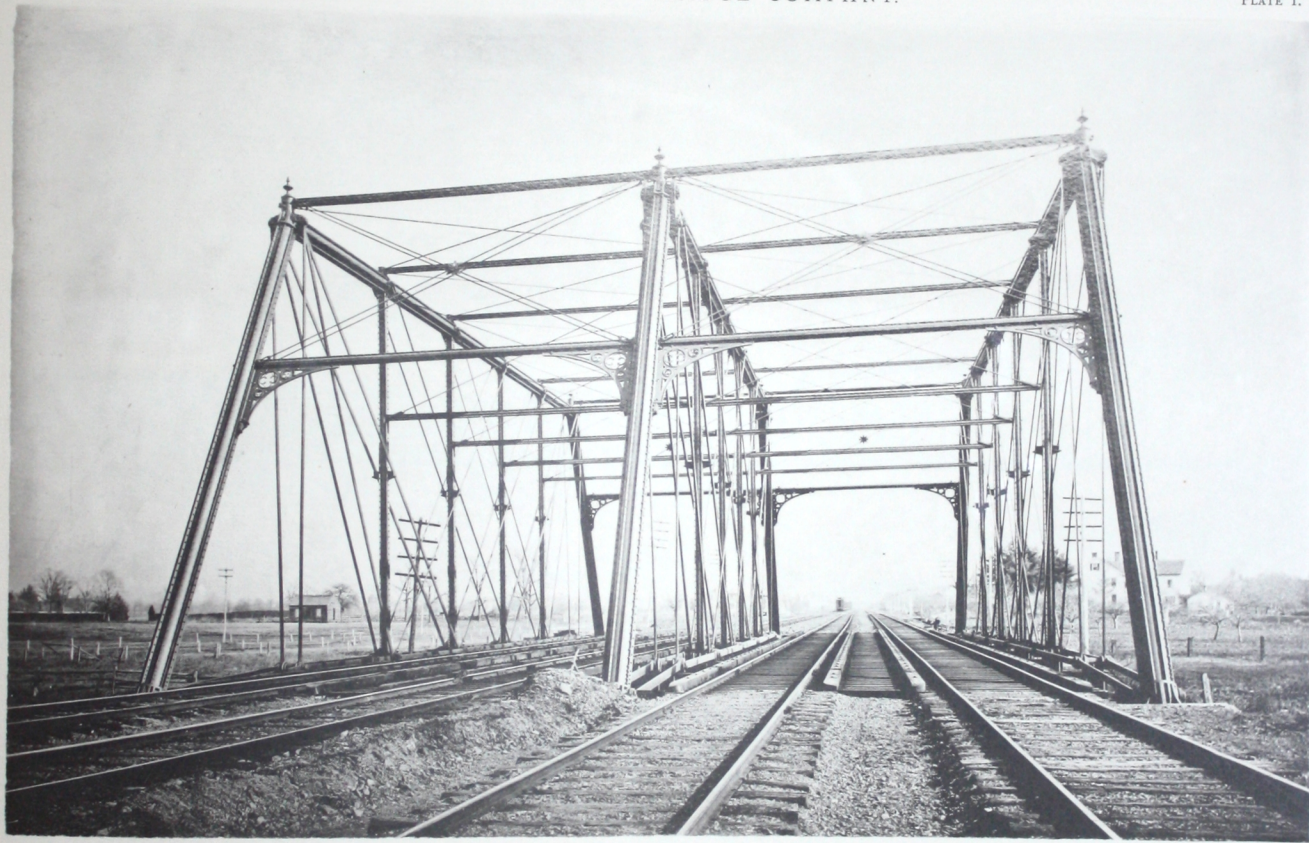
DESIGNED, CONSTRUCTED, AND ERECTED BY

THE PHOENIX BRIDGE COMPANY.



THE PHŒNIX BRIDGE COMPANY.

PLATE I.



FOUR-TRACK RAILWAY BRIDGE OVER MIDDLE BROOK,
CENTRAL RAILROAD OF NEW JERSEY DIVISION PHILADELPHIA AND READING RAILROAD.



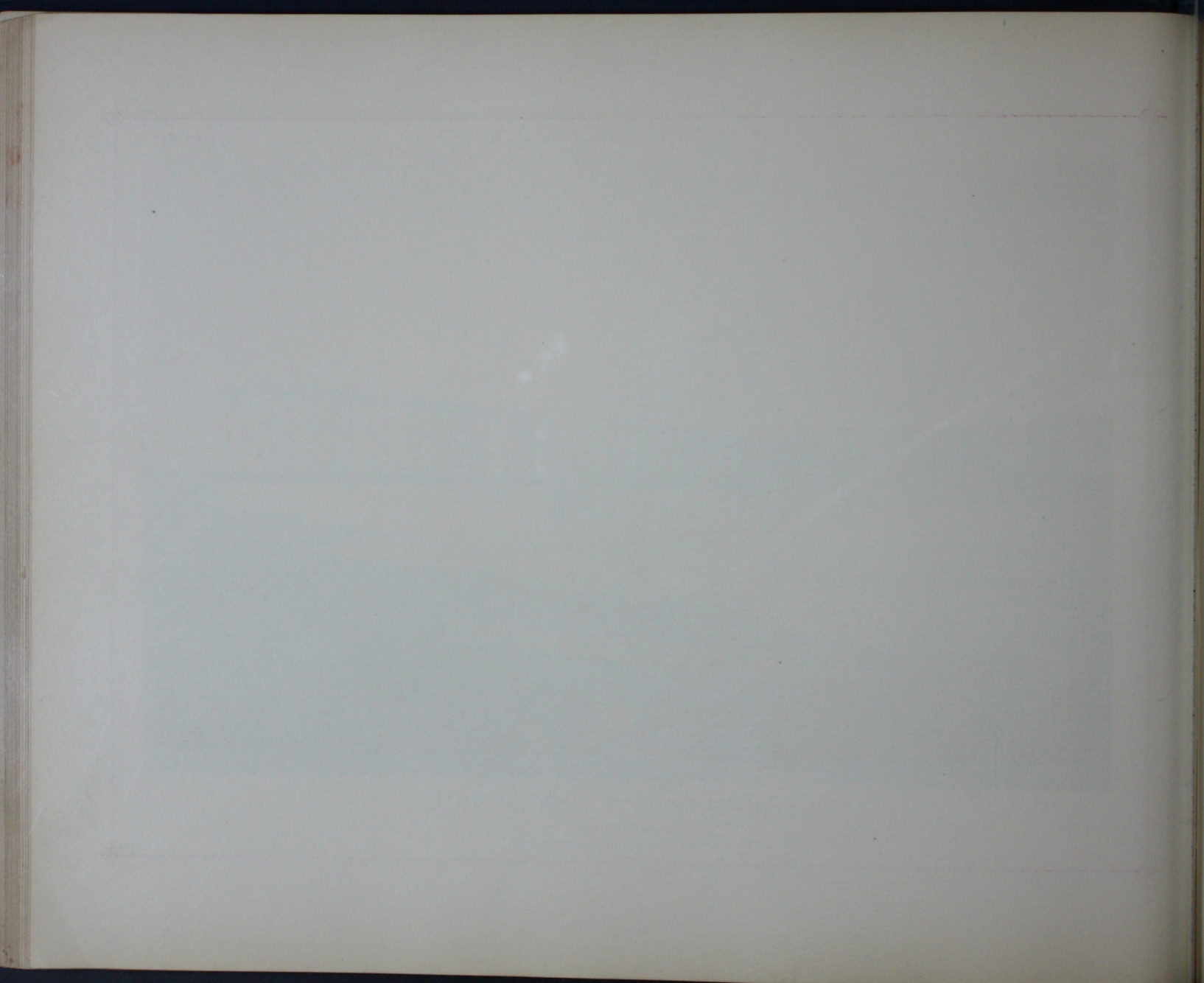
THE PHŒNIX BRIDGE COMPANY.

PLATE II.



SUSQUEHANNA RIVER BRIDGE,
SUNBURY, PA.

SINGLE-TRACK THROUGH BRIDGE OF FOURTEEN SPANS.

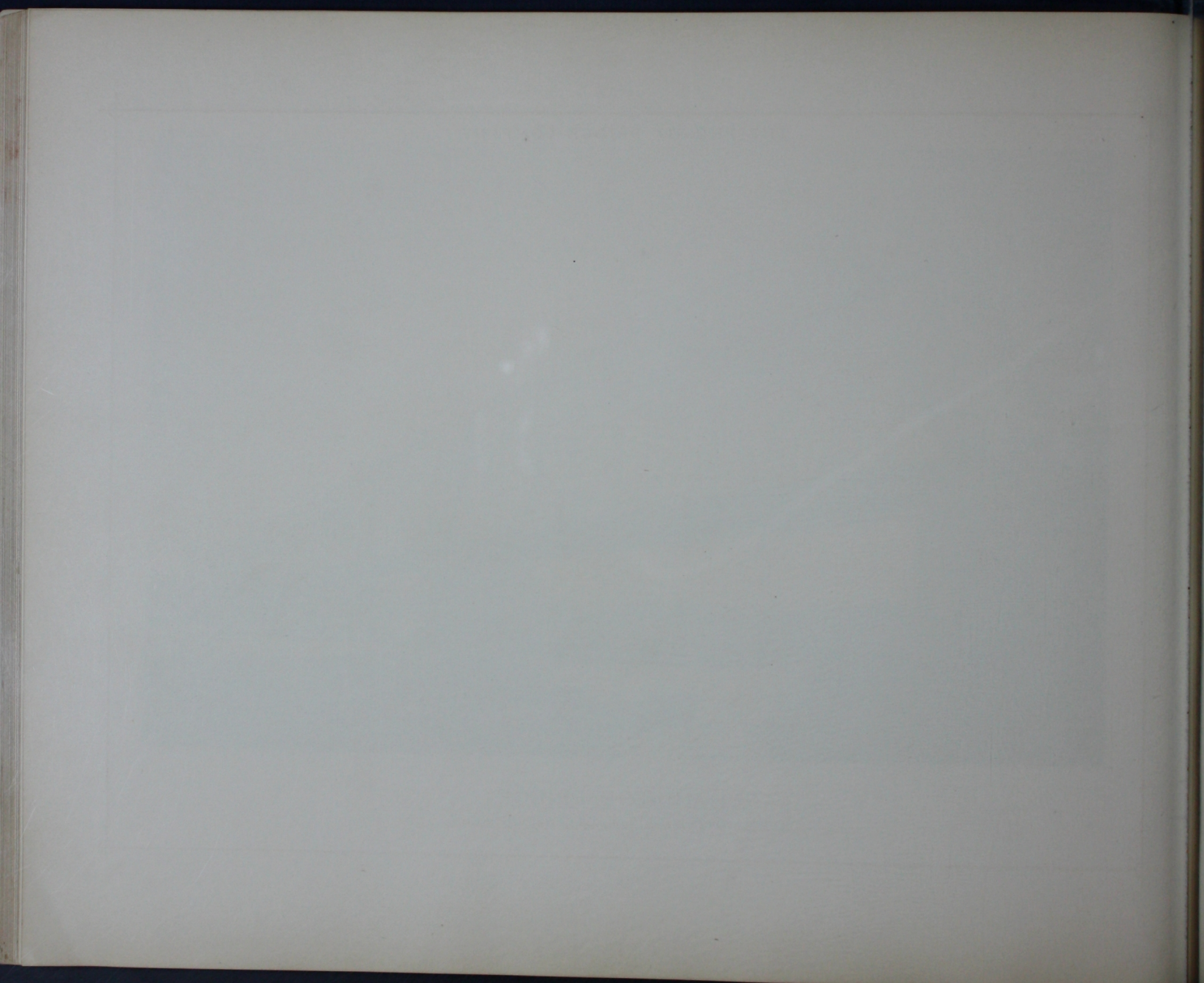


THE PHOENIX BRIDGE COMPANY.

PLATE III.



CHAUDIERE BRIDGE,
ACROSS OTTAWA RIVER, OTTAWA, ONTARIO.



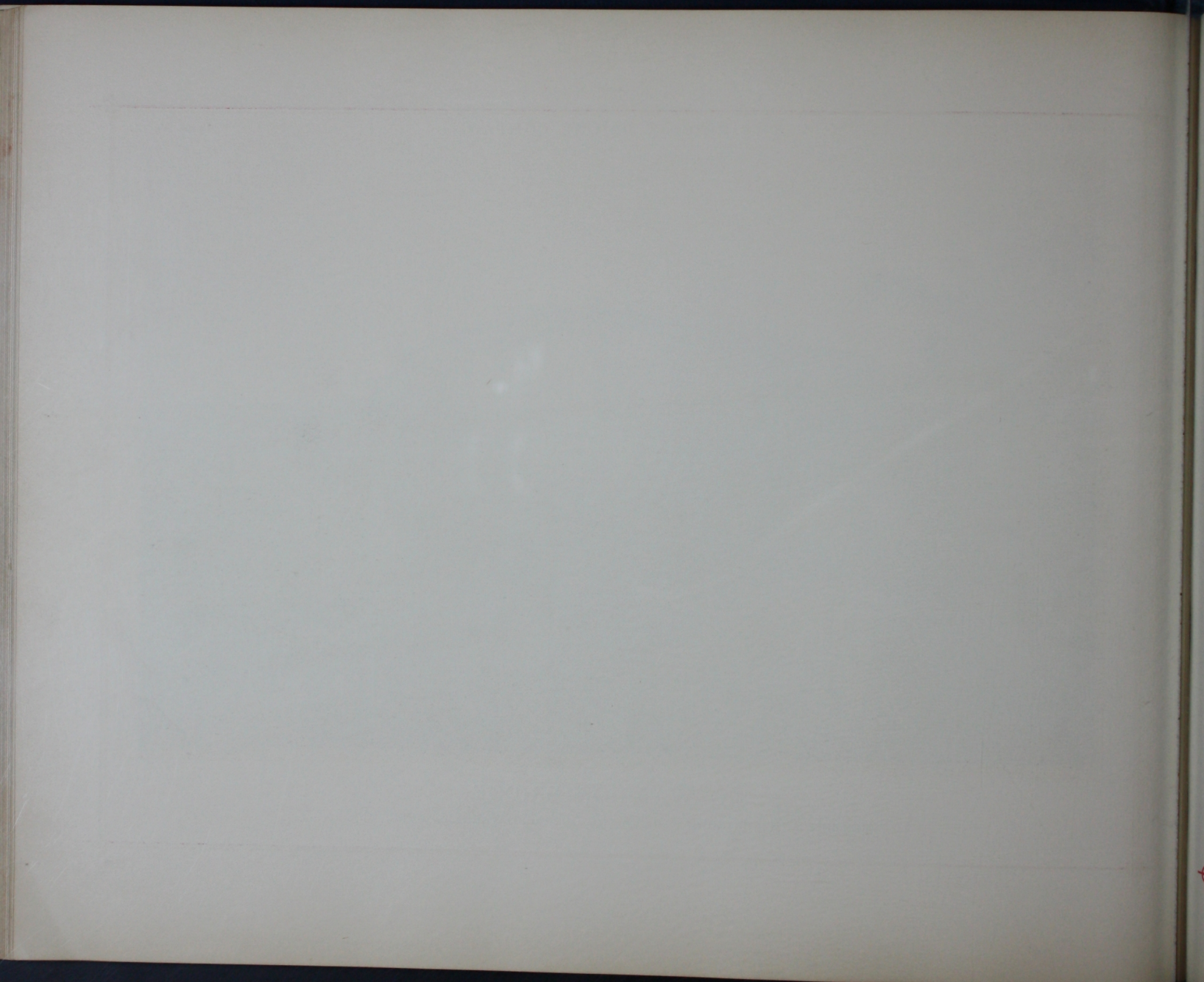
THE PHŒNIX BRIDGE COMPANY.

PLATE IV.



BIG WARRIOR BRIDGE,

MEMPHIS AND BIRMINGHAM RAILROAD, OVER BIG WARRIOR RIVER, ALA.



THE PHŒNIX BRIDGE COMPANY.

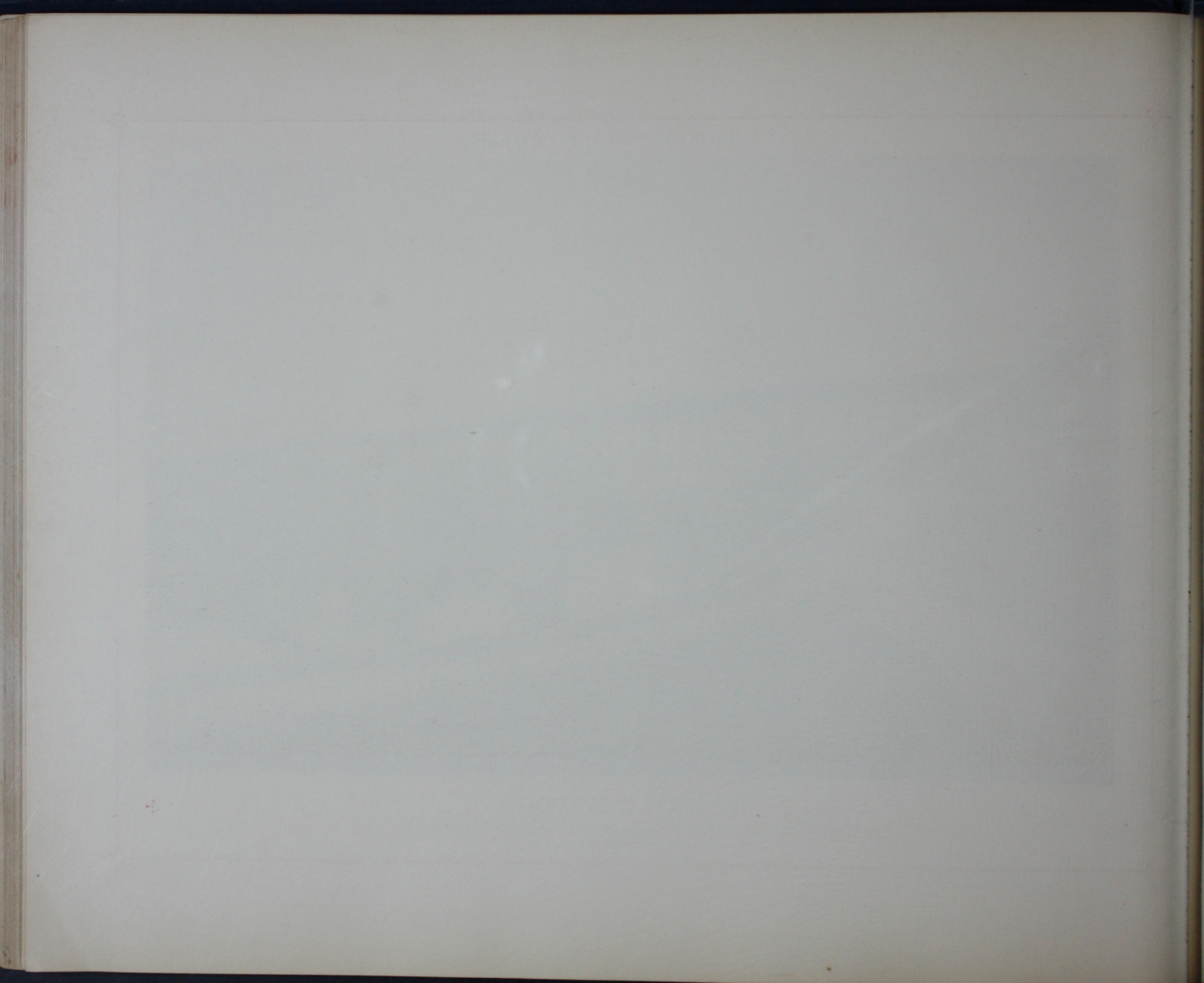
PLATE V.



CATSKILL BRIDGE.

NEW YORK, WEST SHORE AND BUFFALO RAILROAD COMPANY.

DOUBLE-TRACK DECK BRIDGE OF EIGHT SPANS



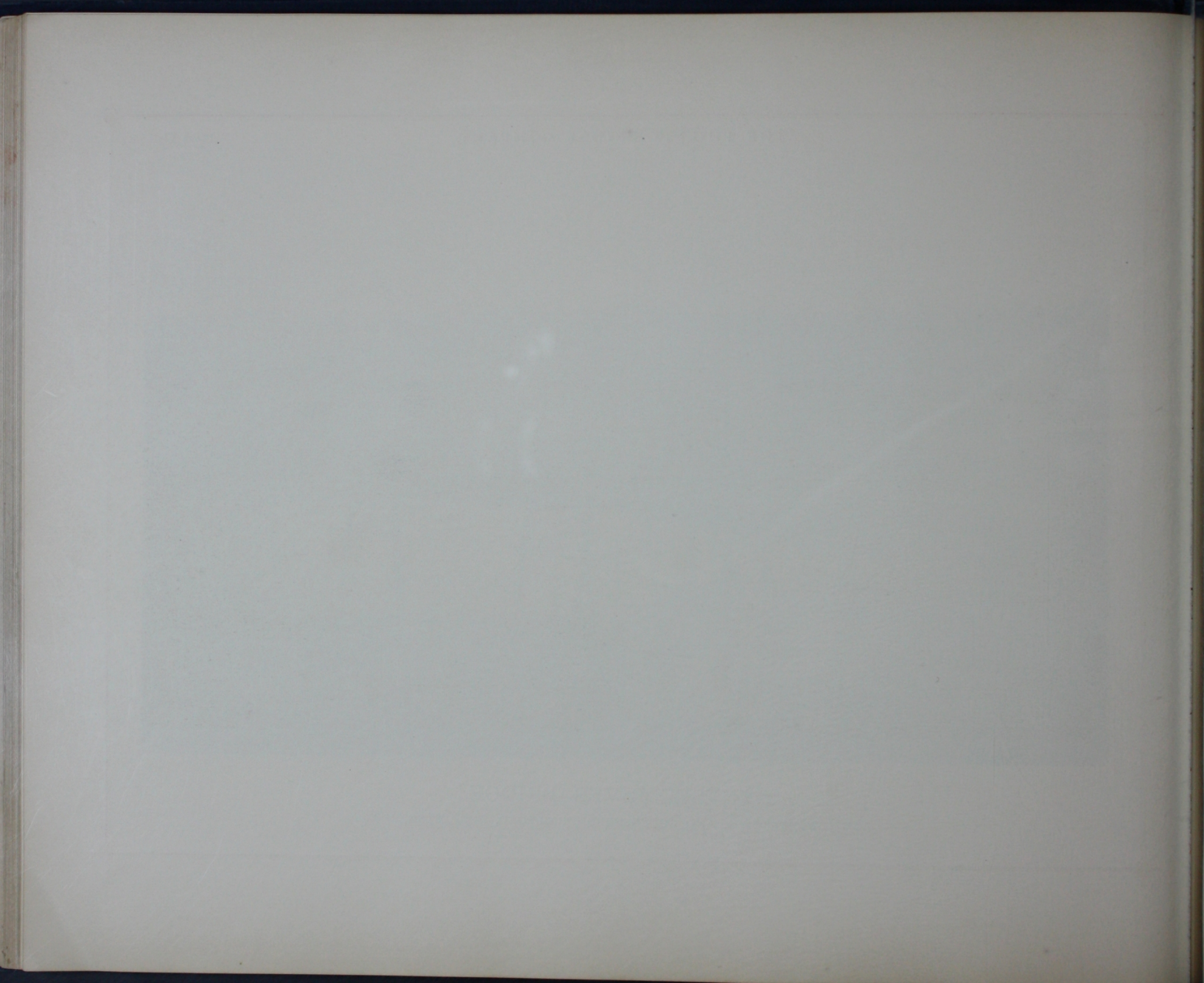
THE PHOENIX BRIDGE COMPANY.

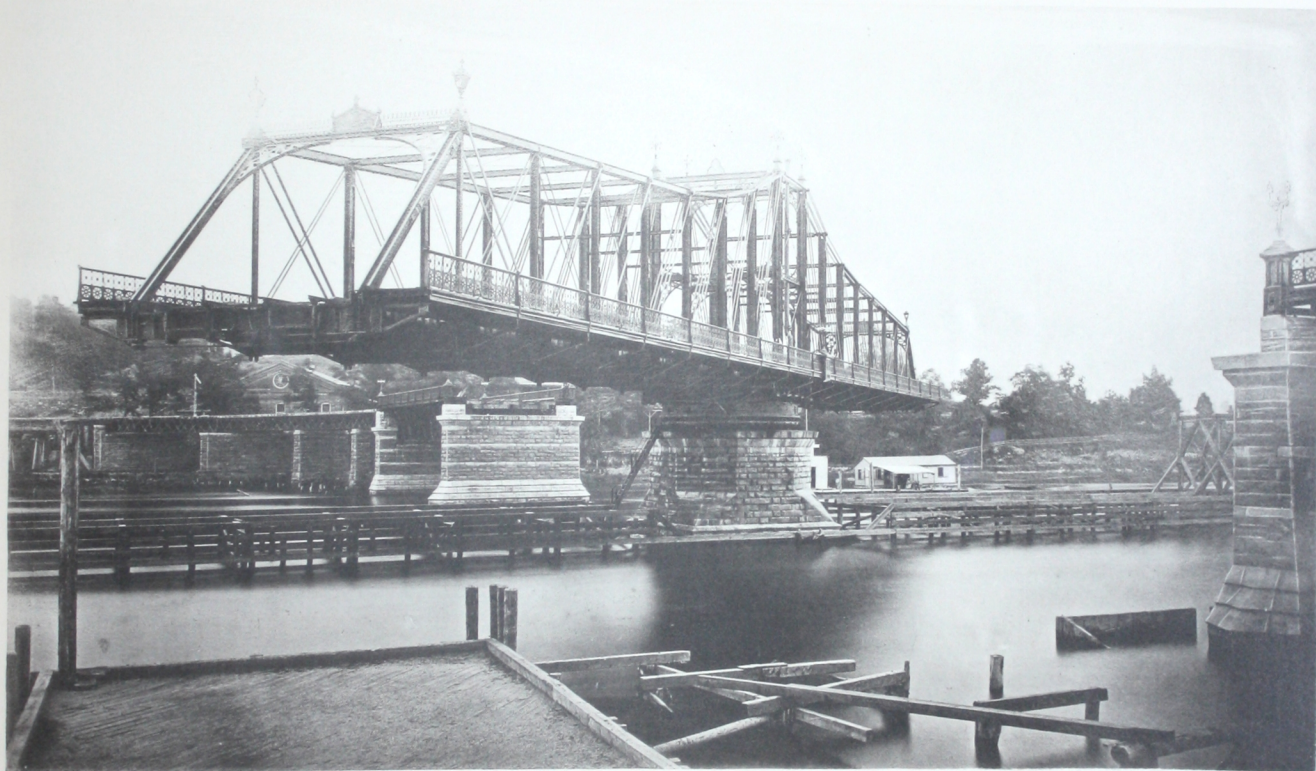
PLATE VI.



GENESEE RIVER BRIDGE,

ROME, WATERTOWN, AND OGDENSBURGH RAILROAD, ROCHESTER, N. Y.

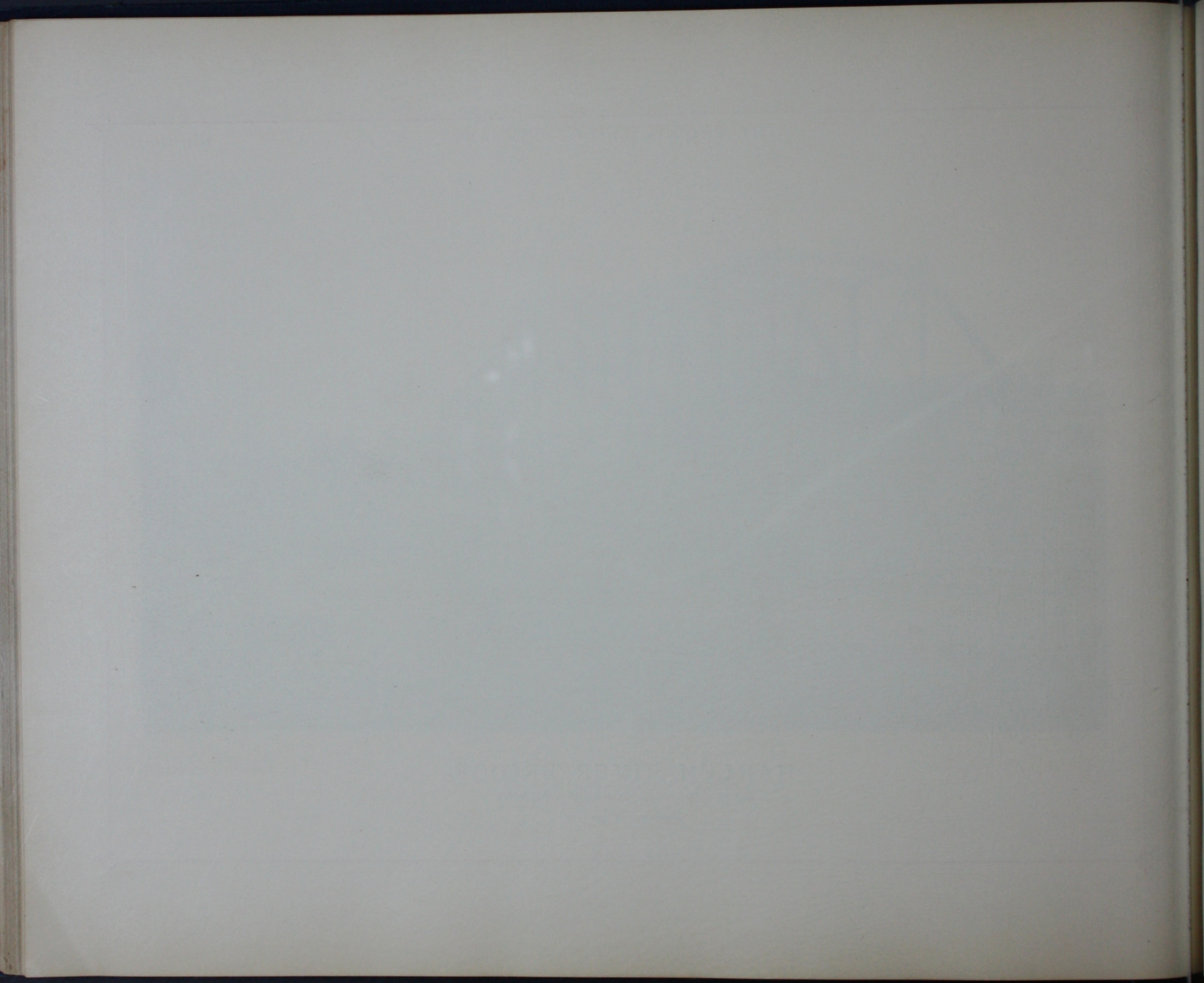




HARLEM RIVER BRIDGE,

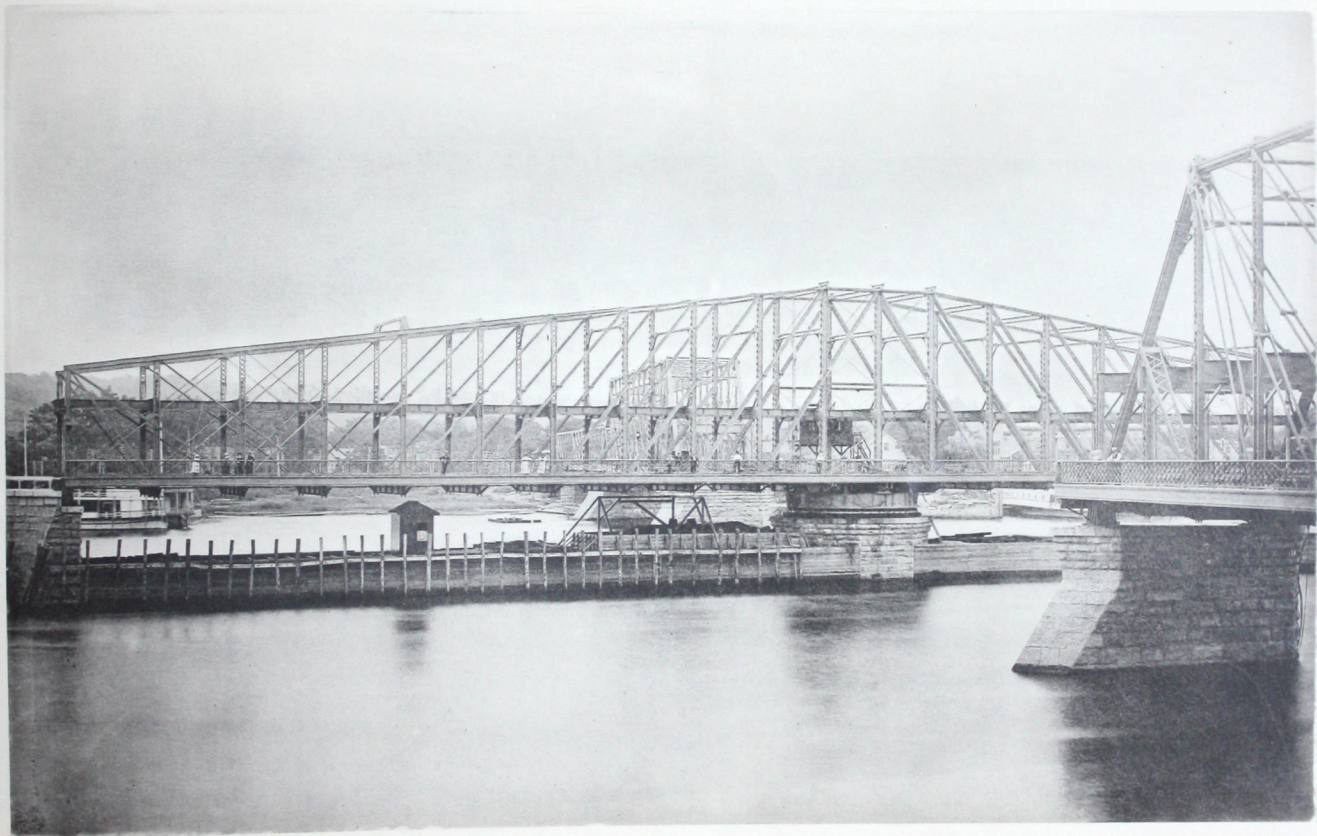
WEST SIDE AND YONKERS RAILWAY,

EIGHTH AVENUE, NEW YORK.



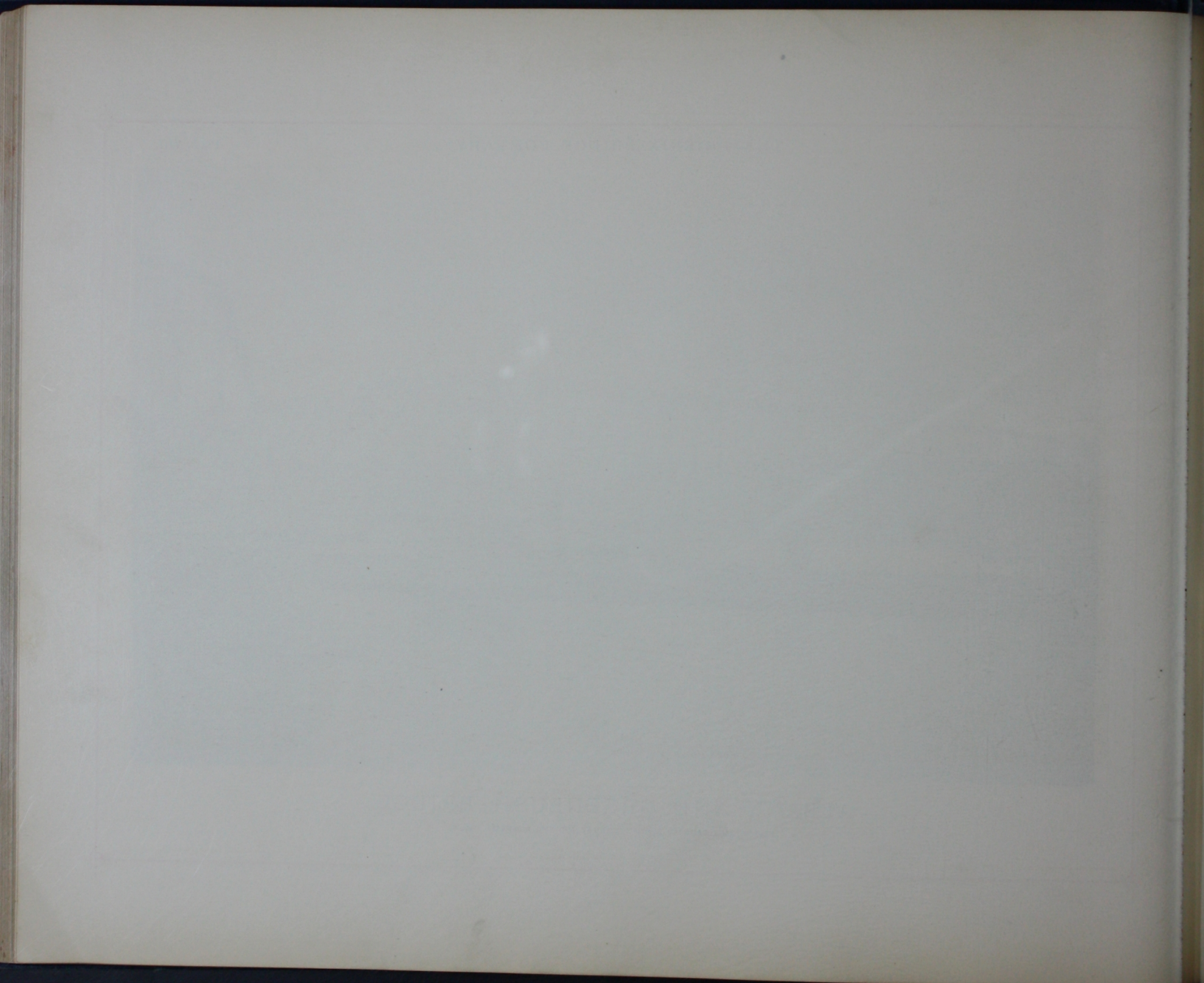
THE PHOENIX BRIDGE COMPANY.

PLATE VIII.



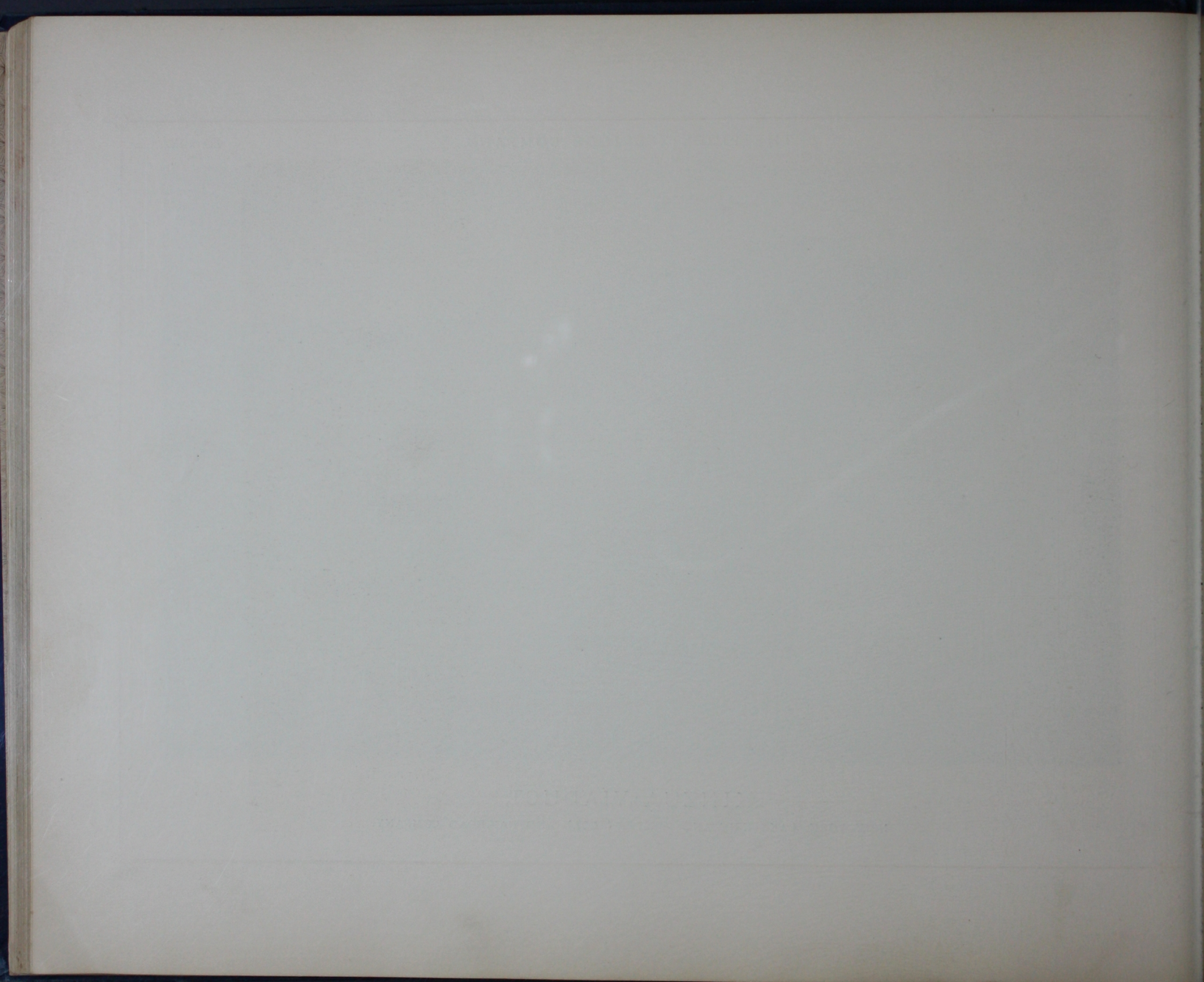
ALBANY AND GREENBUSH BRIDGE.

DOUBLE-TRACK RAILROAD ABOVE. ROADWAY AND TWO SIDEWALKS BELOW.



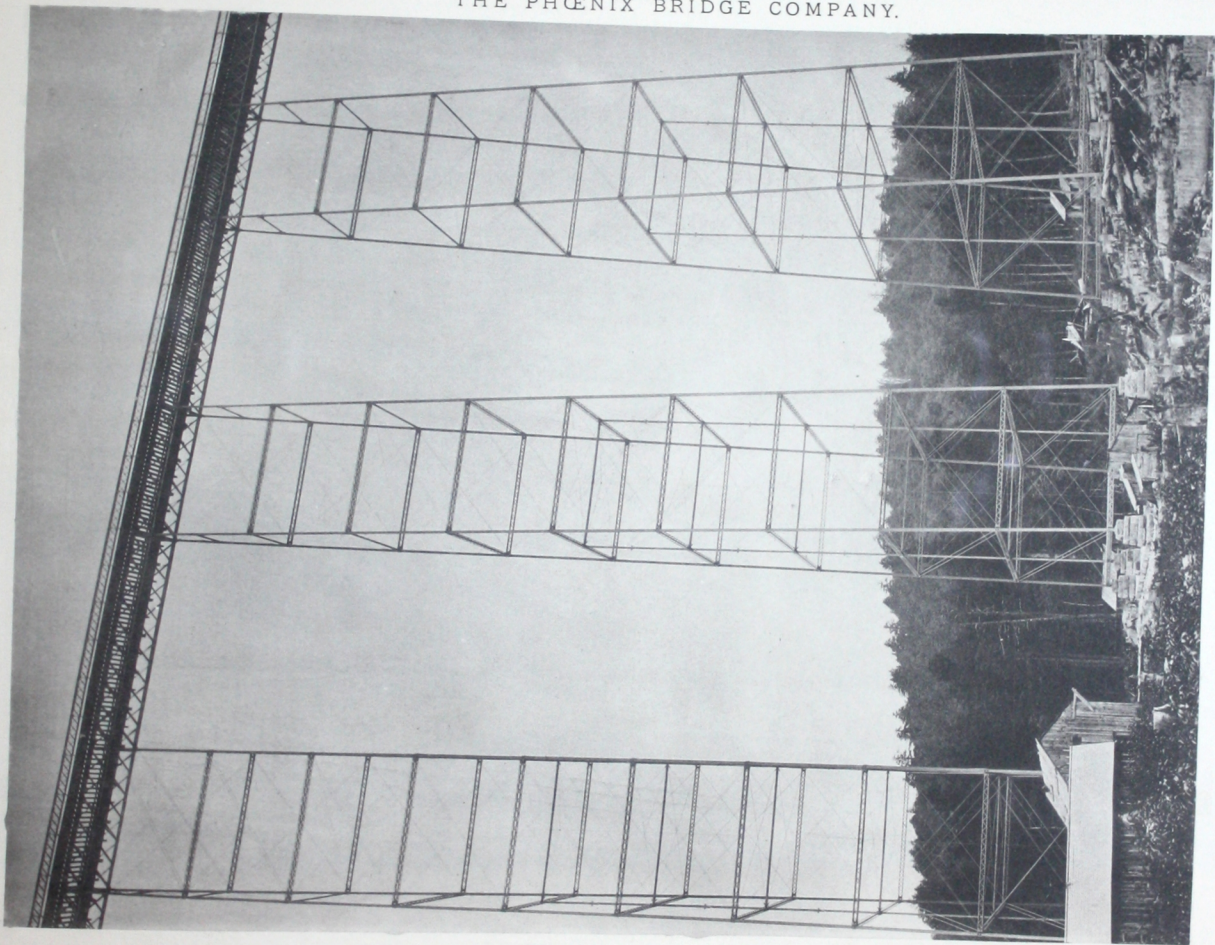


KINZUA VIADUCT,
NEW YORK, LAKE ERIE AND WESTERN COAL AND RAILROAD COMPANY.



THE PHOENIX BRIDGE COMPANY.

PLATE X.



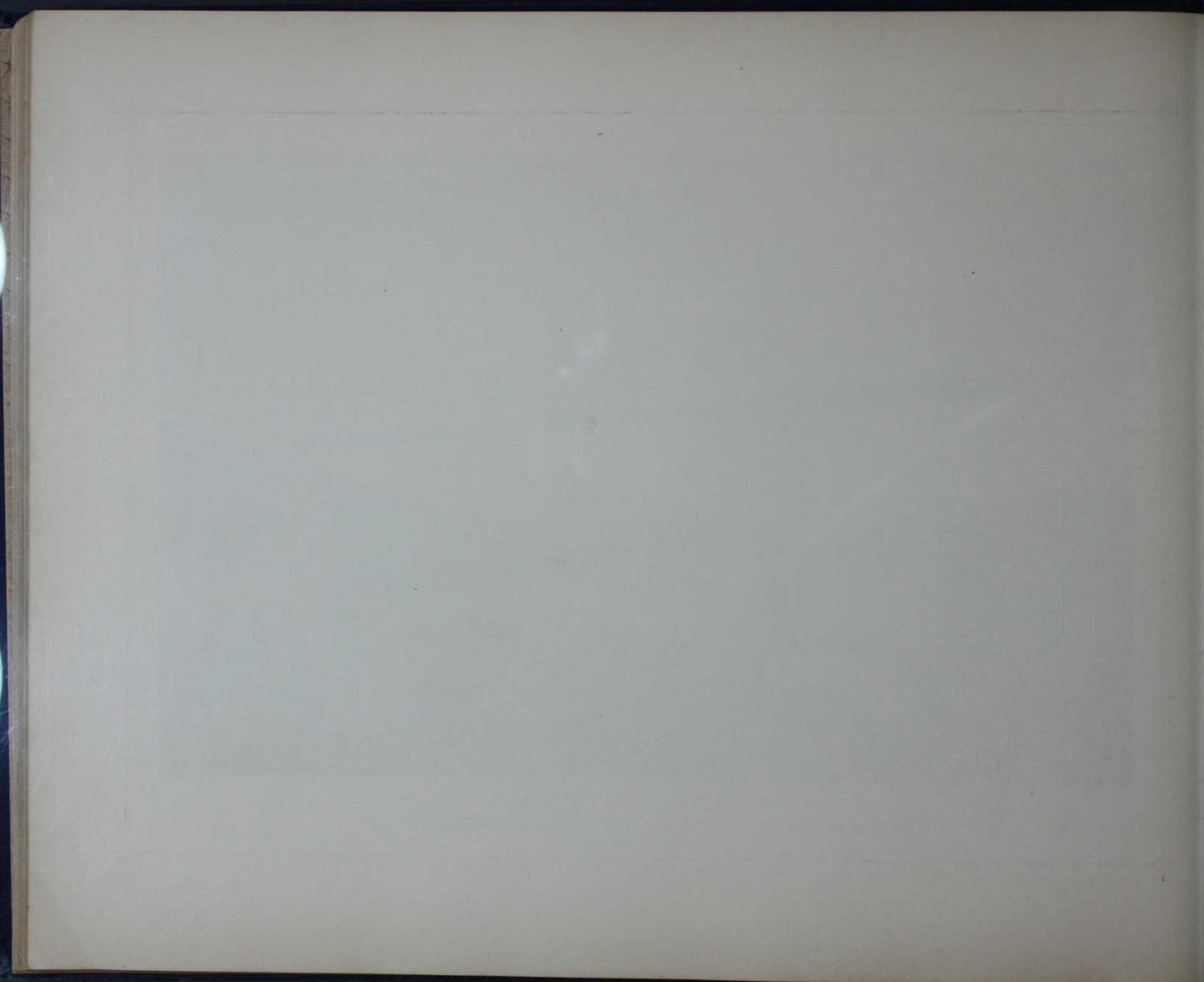
KINZUA VIADUCT,

NEW YORK, LAKE ERIE AND WESTERN COAL AND RAILROAD COMPANY.

THE UNIVERSITY OF CHICAGO
LIBRARY

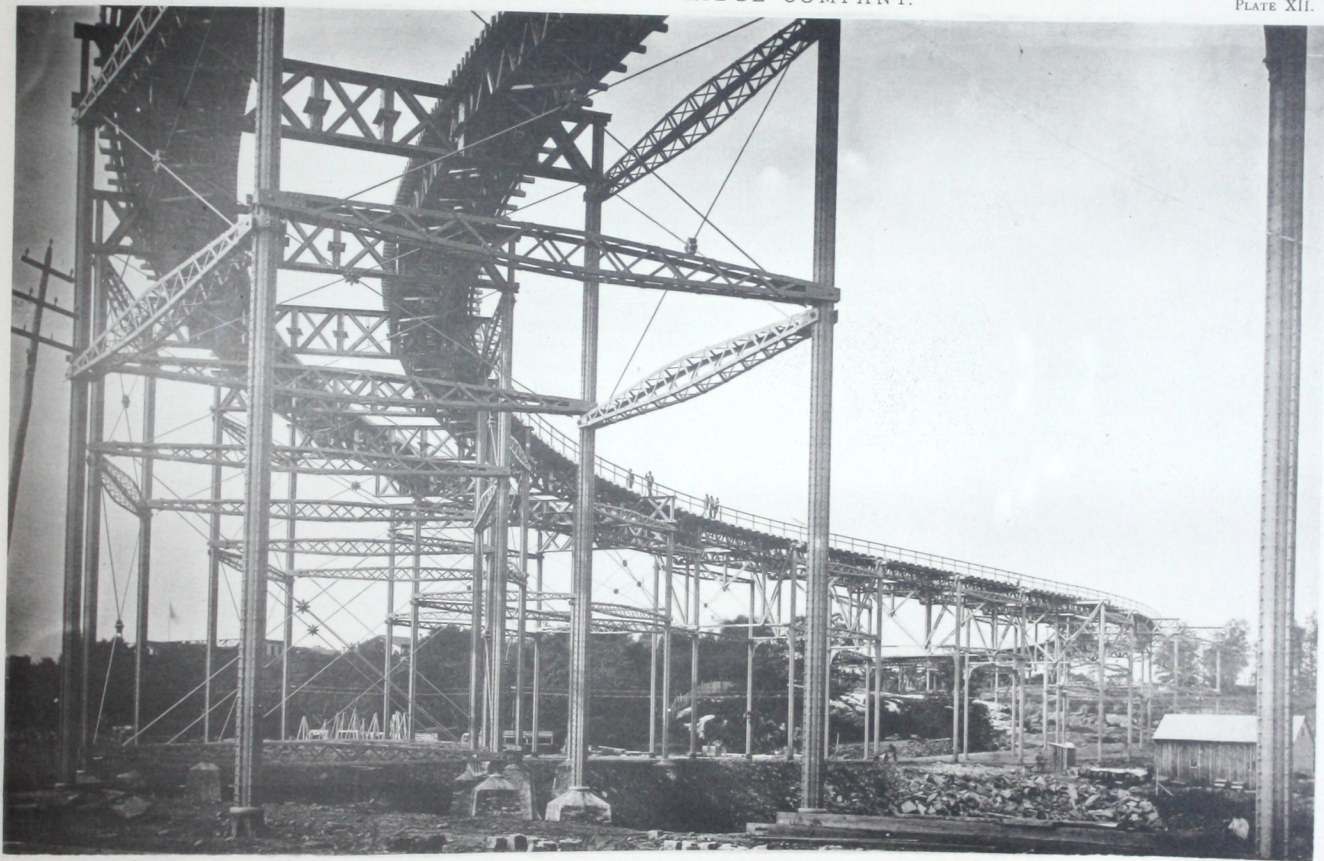


RONDOUT BRIDGE,
NEW YORK, WEST SHORE AND BUFFALO RAILROAD COMPANY.
DOUBLE-TRACK THROUGH BRIDGE AND VIADUCT.

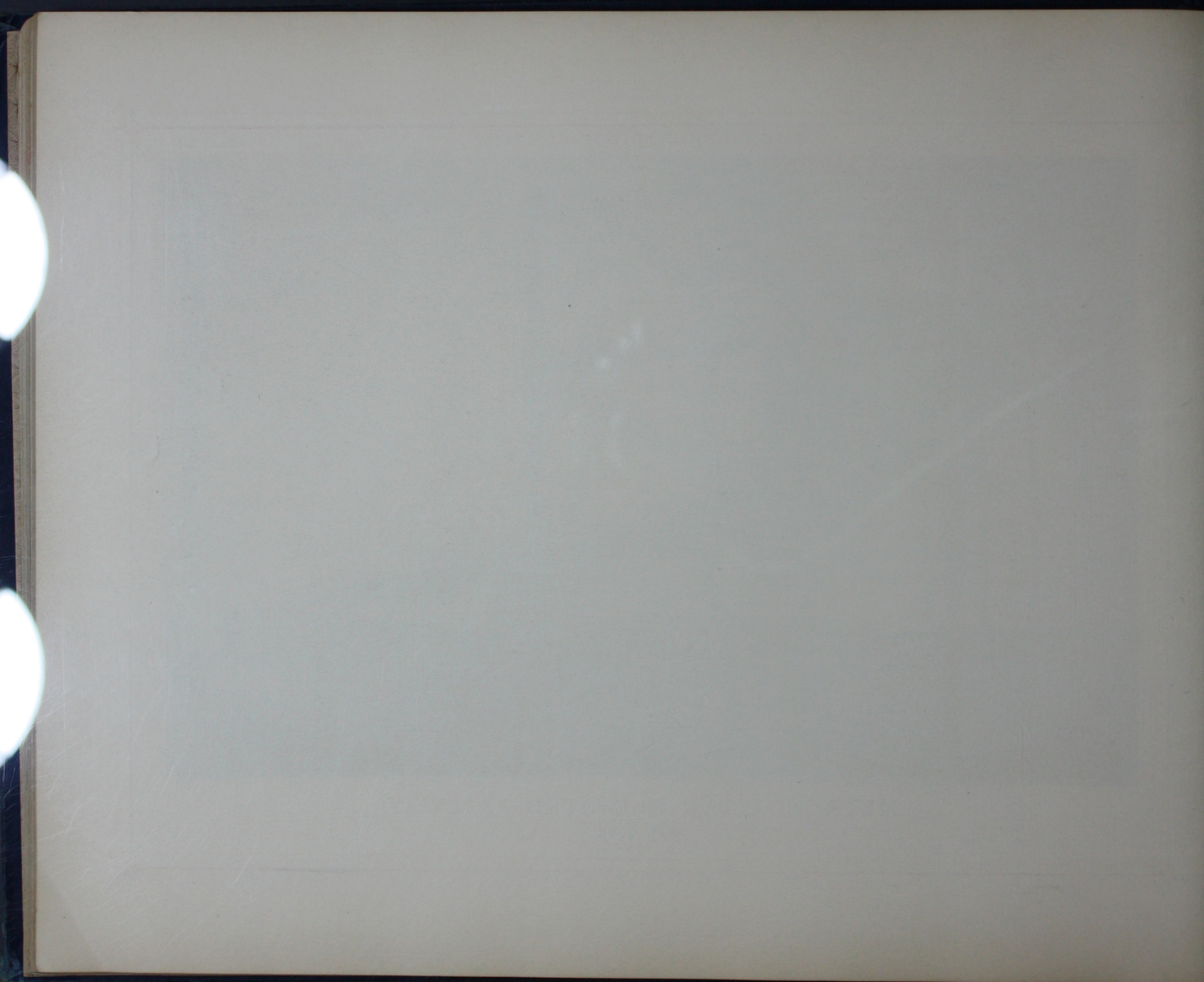


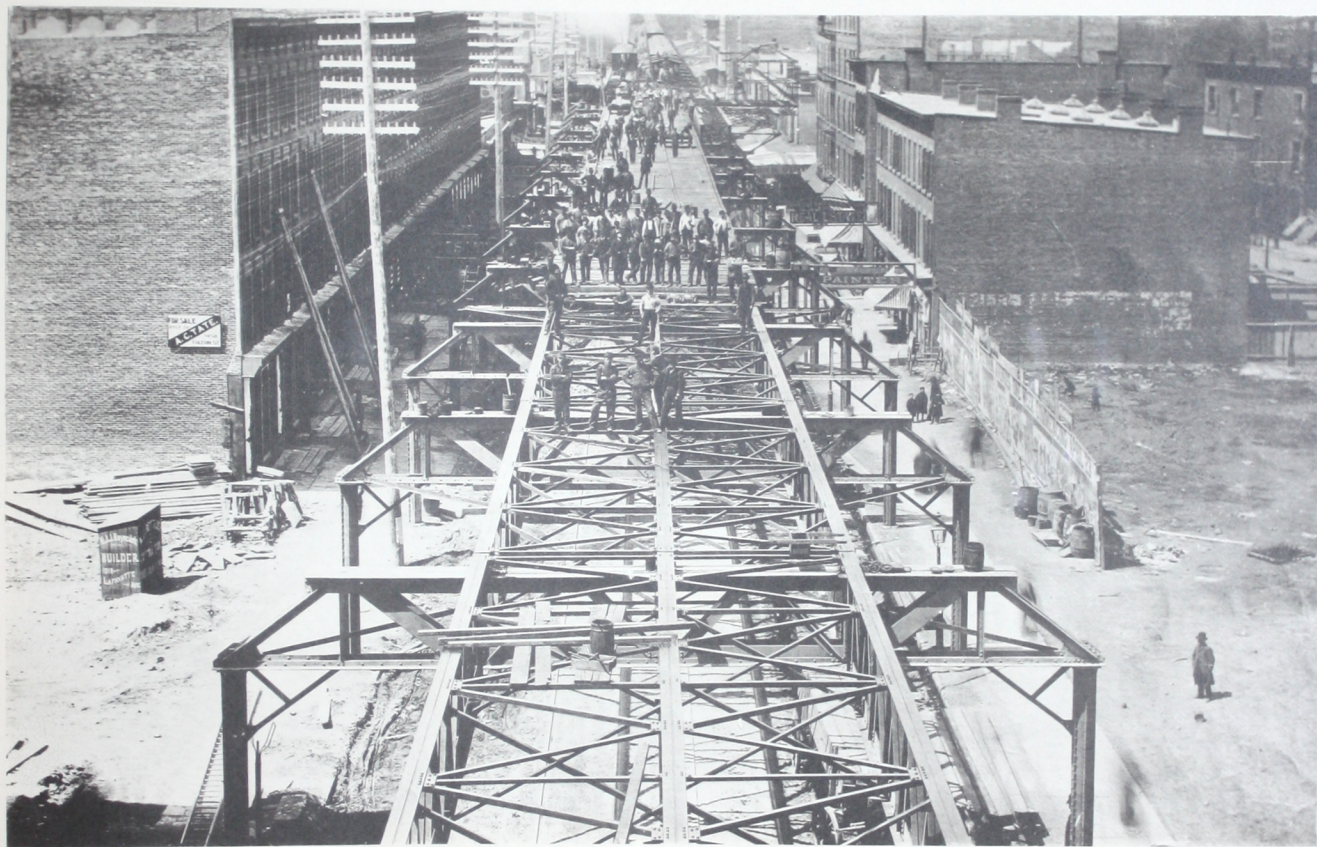
THE PHOENIX BRIDGE COMPANY.

PLATE XII.

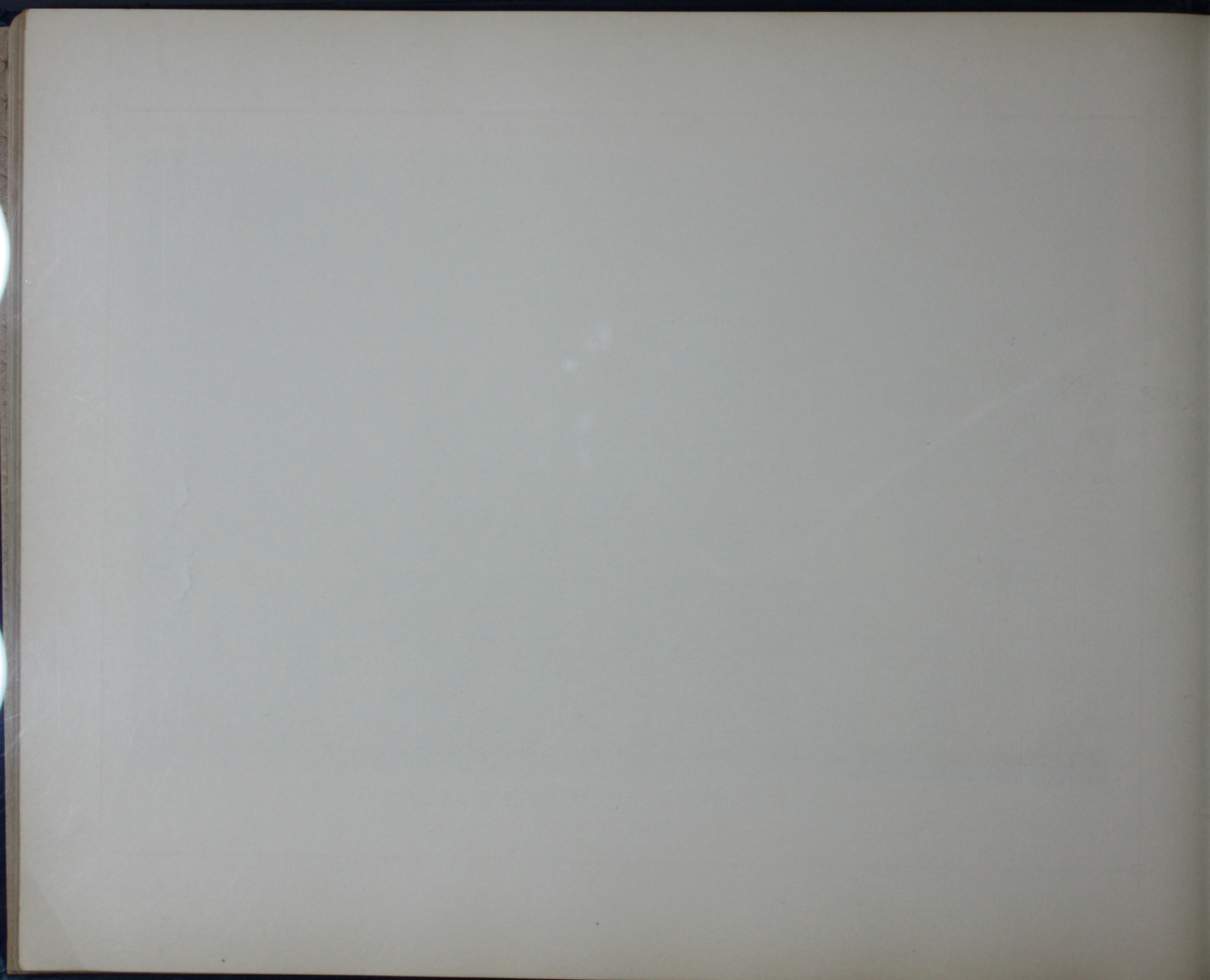


METROPOLITAN ELEVATED RAILWAY,
NEW YORK.



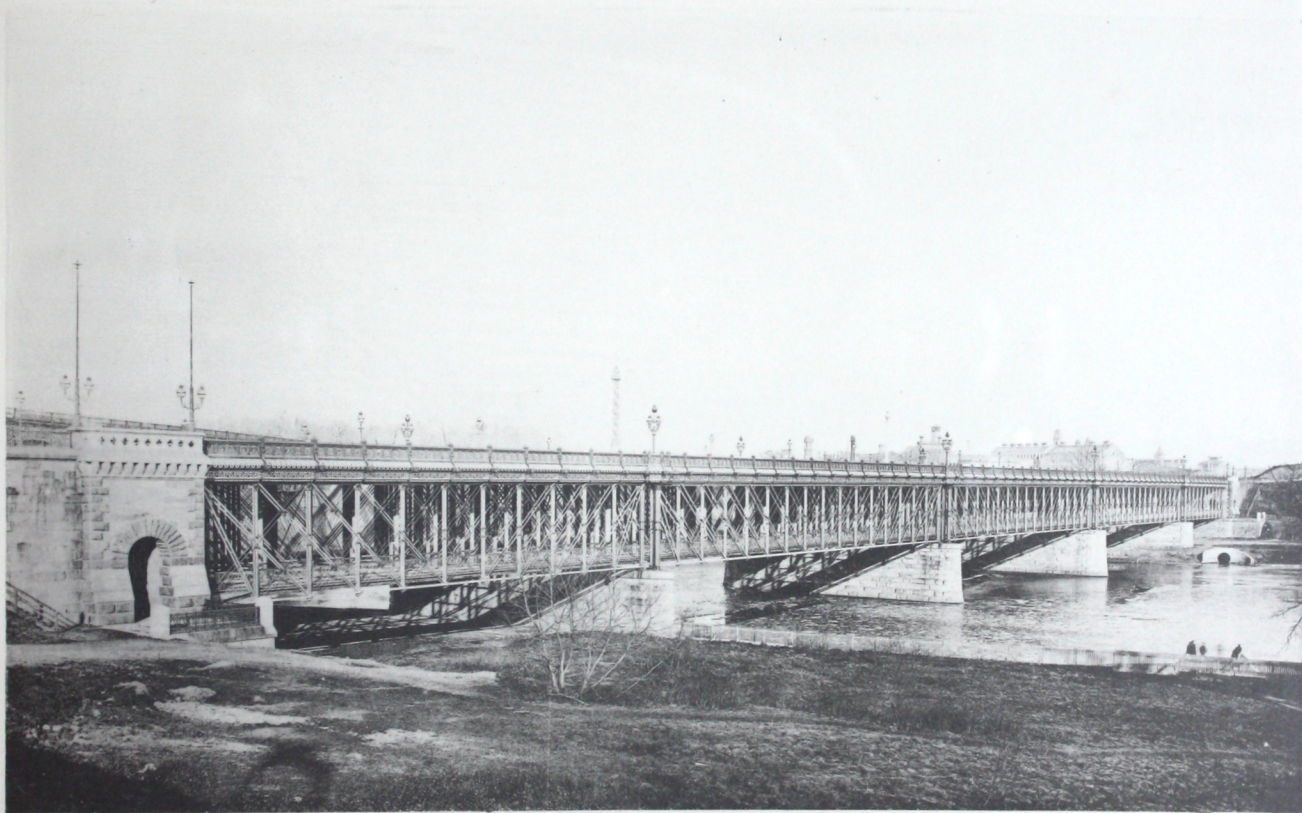


KINGS COUNTY ELEVATED RAILWAY,
BROOKLYN, N. Y.

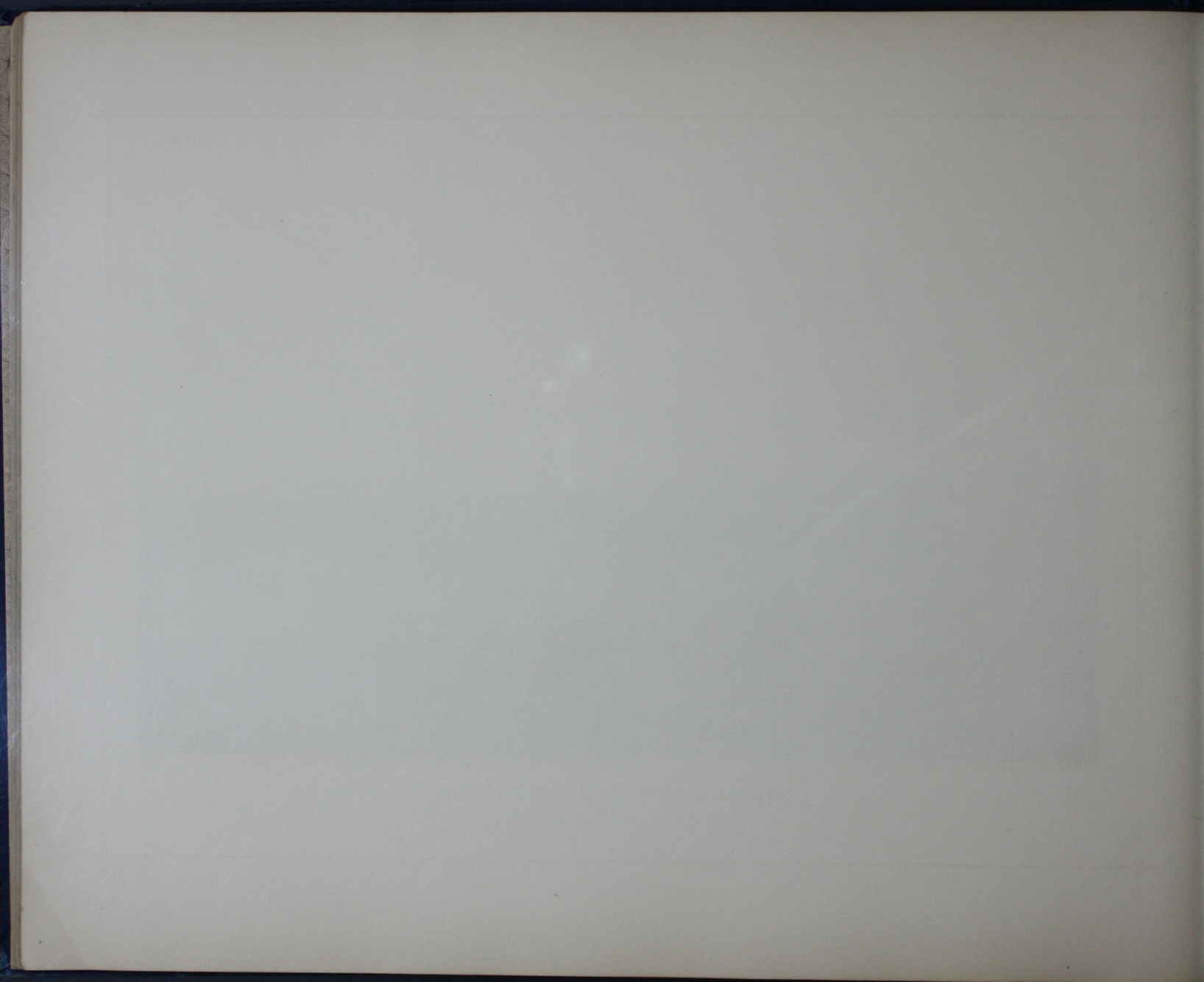


THE PHŒNIX BRIDGE COMPANY.

PLATE XIV.



GIRARD AVENUE BRIDGE,
PHILADELPHIA, PA.

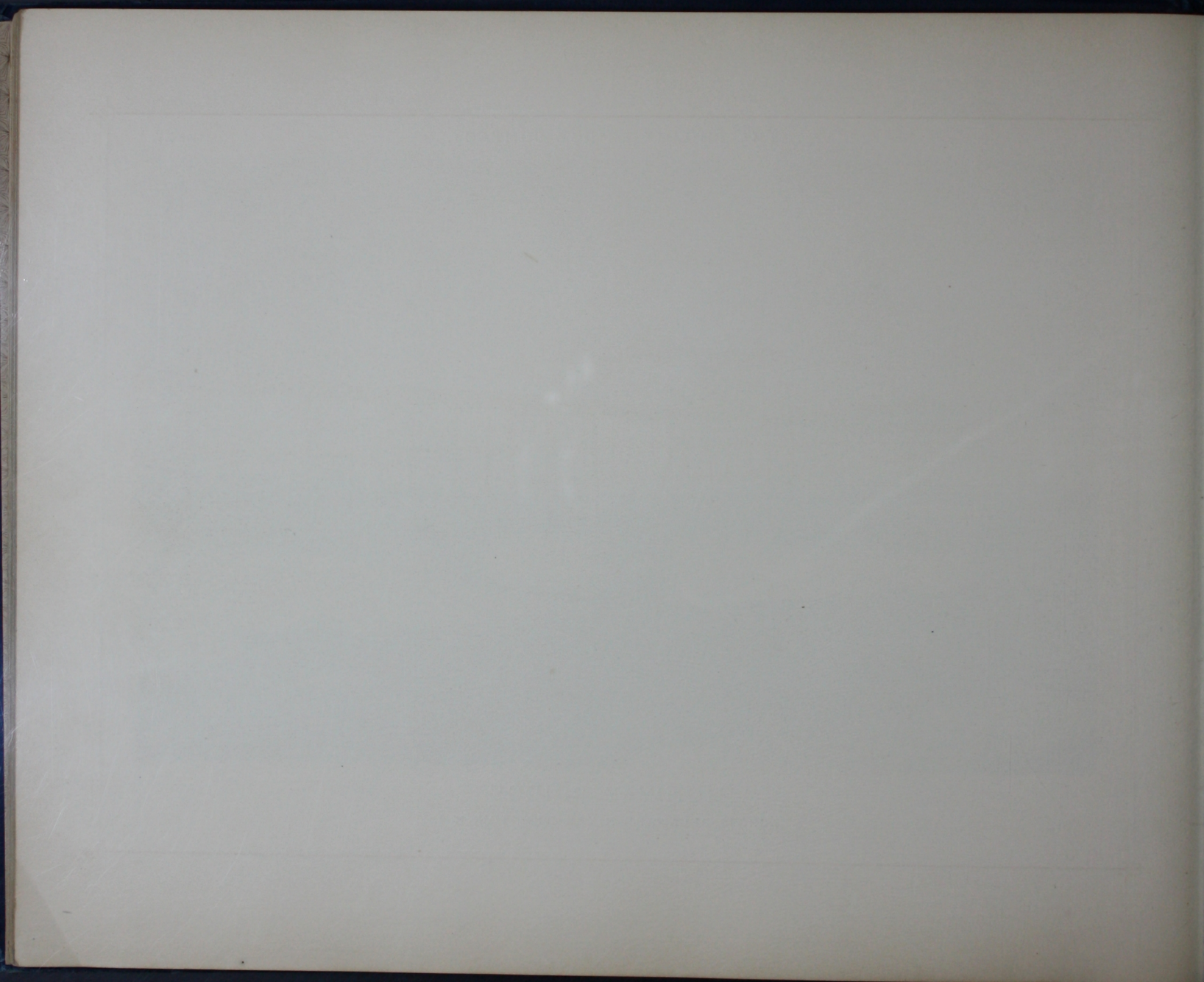


THE PHOENIX BRIDGE COMPANY.

PLATE XV.



HIGHWAY BRIDGE,
ACROSS DELAWARE RIVER, TRENTON, N. J.

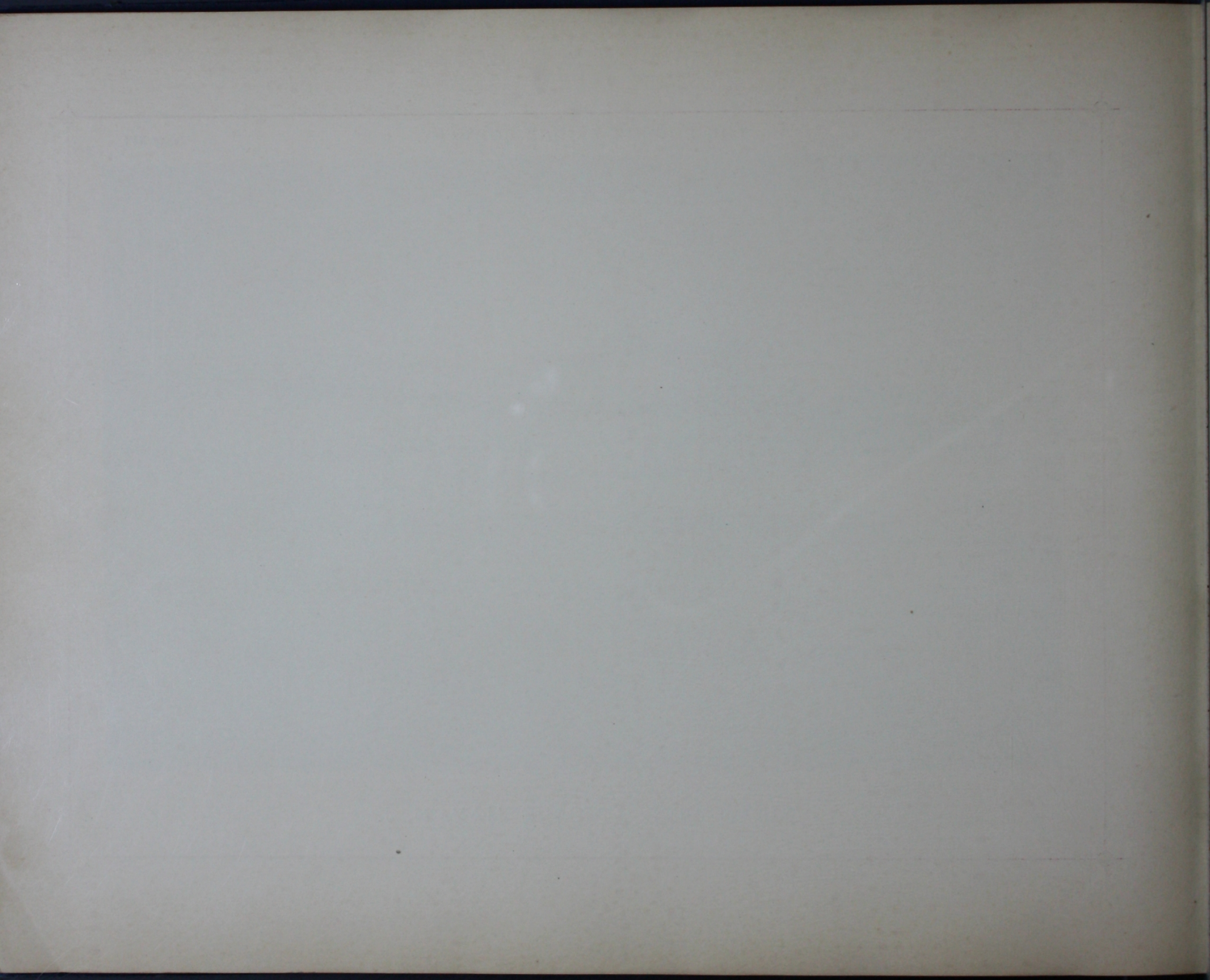


THE PHŒNIX BRIDGE COMPANY.

PLATE XVI.



OCEAN PIER AT CAPE MAY, N. J.



17th



